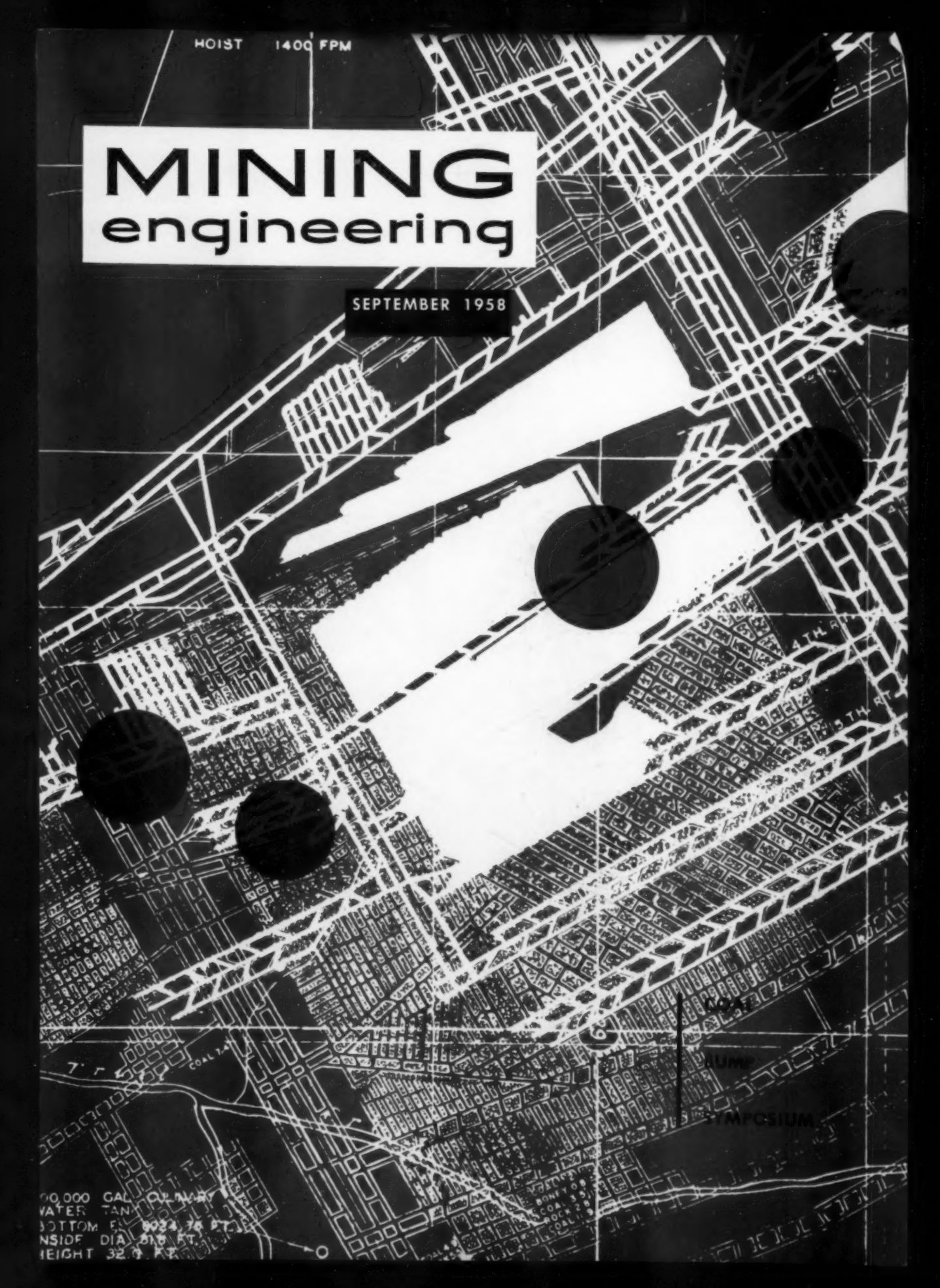
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engineering
SEPTEMBER 1958
COAL
PUMP
SYMPOSIUM

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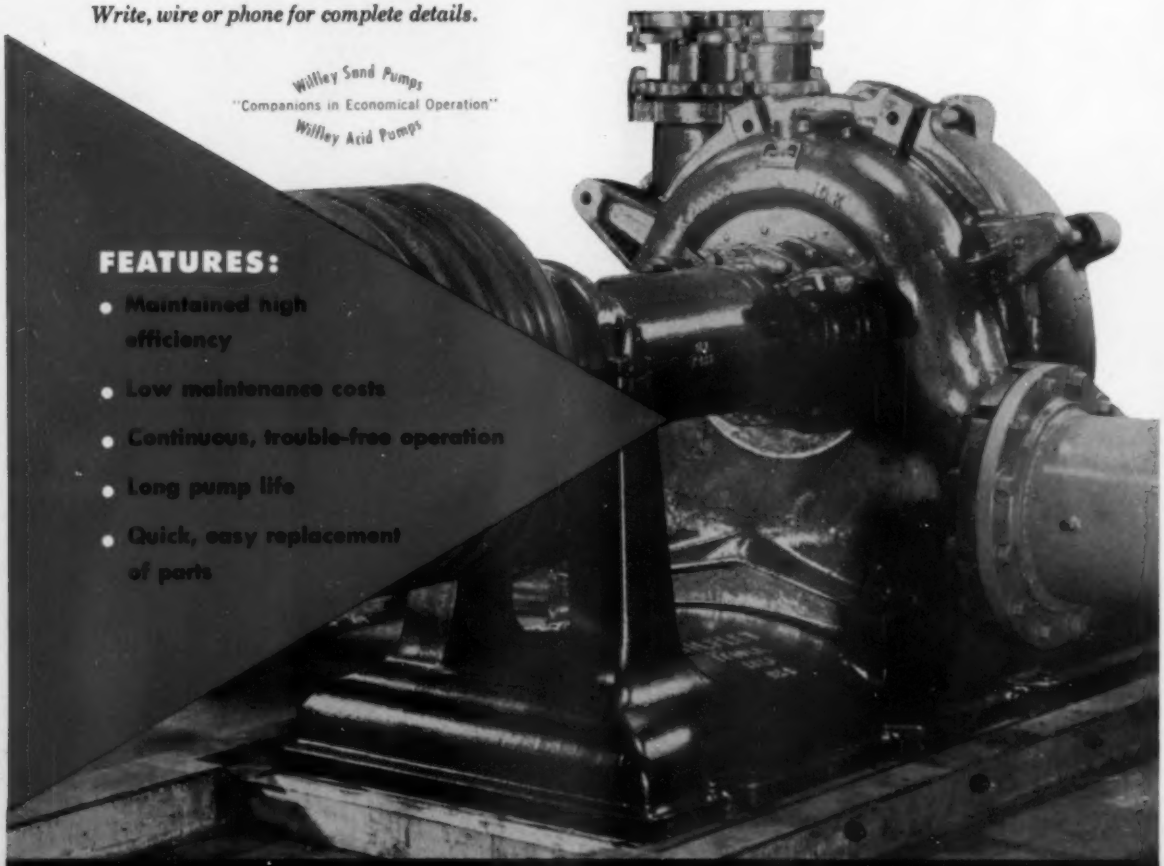

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COMING EVENTS

Sept. 13, AIME Colorado Plateau Section, Aspen, Colo.

Sept. 17-19, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City.

Sept. 18-20, Rocky Mountain Assn. of Geologists, symposium on Pennsylvanian rocks of Colorado and field trip, Maroon Basin, northwest Colorado.

Sept. 20 (tentative), AIME Lehigh Valley Section, tour of "Nike" site, Doylestown, Pa.

Sept. 22-25, American Mining Congress Mining Show, Civic Auditorium, San Francisco.

Sept. 27, AIME Adirondack Section, National Lead trip, Tahawus, N. Y.

Oct. 2-4, Annual Drilling and Blasting Symposium, University of Minnesota, Minneapolis.

Oct. 4, AIME Eastern North Carolina Subsection, Southeast Section, Carolina Inn, Chapel Hill, N. C.

Oct. 9-10, AIME-ASME Solid Fuels Conference, Hotel Chamberlin, Old Point Comfort, Va.

Oct. 9, 10, ECPD annual meeting, Sheraton-Jefferson Hotel, St. Louis.

Oct. 13-16, Soc. of Exploration Geophysicists, annual meeting, Gunter Hotel, San Antonio, Texas.

Oct. 15-17, Energy Resources Conference, Brown Palace Hotel, Denver.

Oct. 16, AIME Utah Section, speaker: L. V. Olson; subject: Progress in Air Pollution Control; Salt Lake City.

Oct. 16-18, 9th Annual Field Conference, New Mexico Geological Soc. in cooperation with Arizona Geological Soc., Black Mesa Basin of northeastern Arizona.

Oct. 20-23, National Clay Conference, Natural History Bldg., Smithsonian Inst., Washington, D. C.

Oct. 23-25, AIME Mid-America Minerals Conference, Chase-Park Plaza Hotels, St. Louis.

Oct. 24, AIME Lehigh Valley Section, technical meeting, Hotel Traylor, Allentown, Pa.

Oct. 31-Nov. 1, AIME Central Appalachian Section and West Virginia Coal Mining Inst., joint meeting, The Greenbrier, White Sulphur Springs, W. Va.

Nov. 7, AIME Pittsburgh Section and AIME NOHC Pittsburgh Section, 13th annual Off-the-Record Meeting, Principal speaker: G. B. Warren, General Electric Co.; Penn-Sheraton Hotel, Pittsburgh.

Nov. 13-14, Missouri School of Mines and Metallurgy, 4th annual symposium on mining research, University of Missouri, Rolla, Mo.

Nov. 14-15, AIME Southeast Section, annual fall meeting, Atlanta.

Nov. 18, AIME Ohio Valley Subsection, President's night—guest: Augustus B. Kinzel; Ricardo's, Columbus, Ohio.

Dec. 1, AIME Arizona Section, annual meeting, Pioneer Hotel, Tucson, Ariz.

Dec. 5, AIME Lehigh Valley Section, ladies' night, Speaker: Augustus B. Kinzel; Lehigh Valley Club, Allentown, Pa.

Dec. 6, AIME Eastern North Carolina Subsection, Southeast Section, Hotel Vance, Henderson, N. C.

Dec. 11, AIME Utah Section, panel discussion on Place of Research in the Minerals Industries; members: chairman J. M. Ehrhorn, S. R. Zimmerley, J. B. Clemmer, W. M. Fassell, Jr., J. R. Lewis; Salt Lake City.

Jan. 12, 1959, AIME Minnesota Section, annual meeting, Duluth.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Duluth.

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

MINING engineering

Vol. 10 NO. 9 SEPTEMBER 1958

COVER *This month's cover by artist Herb McClure shows part of the workings of Kaiser's Sunnyside coal mine in Utah. Red circles are sites of bumps which occurred in early development stage—more of this story begins on page 982.*

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977 Precision Survey for Tunnel Control • *D. D. Donald*

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Published monthly by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 West 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S. & North, South, & Central America; $10 foreign; $6 for AIME members, or $4 additional for members only in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies, $.75; single copies foreign, $1.00; special issues, $1.50. The AIME is not responsible for any statement made or opinion expressed in its publications.

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Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Second class mail privileges authorized at New York, N. Y. and additional entry established at Manchester, N. H. Number of copies printed of this issue 15,200.

PERSONNEL

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 8c in stamps (no stamped envelopes) for forwarding and returning application. The applicant agrees, if placed in a position by means of the Personnel Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter or $12 a year.

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Engineers. a) *Chief Design Engineer,* mining or metallurgical, B.S., M.E., E.E., mining or metallurgy, under 50, with knowledge of mining, metallurgy, and wide experience in the mining industry, preferably nonferrous. Will supervise mechanical, civil, architectural, structural, process, and electrical engineering group. Salary, up to $15,000. b) *Chief Estimator,* B.S. in engineering, under 50. Ten years experience in construction and mining work, with a knowledge of estimating, mining, and metallurgical plants. Supervise small group and handle project study estimating, as well as estimating for plant design. Salary, to $12,000. Location, western U. S. S3619.

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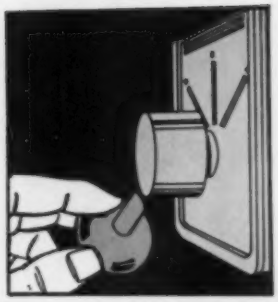
BOOKS

Order directly from the publisher all books listed below except those marked • • • *The books so marked* (• • •) *can be purchased through AIME, usually at a discount. Address Irene K. Sharp, Book Dept., AIME, 29 W. 39th St., New York 18, N. Y.*

Conveyor Terms and Definitions, Book No. 101, *Conveyor Equipment Manufacturers Assn.,* 1 Thomas Circle, Washington 5, D. C., 96 pp., $2.00, 1958.—This book defines more than 1200 conveyor types, parts, and related equipment. Major product, safety, and sanitation standards are listed with their sponsoring organizations. The provisions of the recently revised safety code, B20.1-1957, are included. The American Standard MH4.1-1958 section is available alone, with standard punching for inclusion with other standards, as *Book No. 102* at $1.50. Both books contain a list of CEMA members and a short description of the industry's scope and history.

(Continued on page 929)

Superior crusher with Hydroset mechanism



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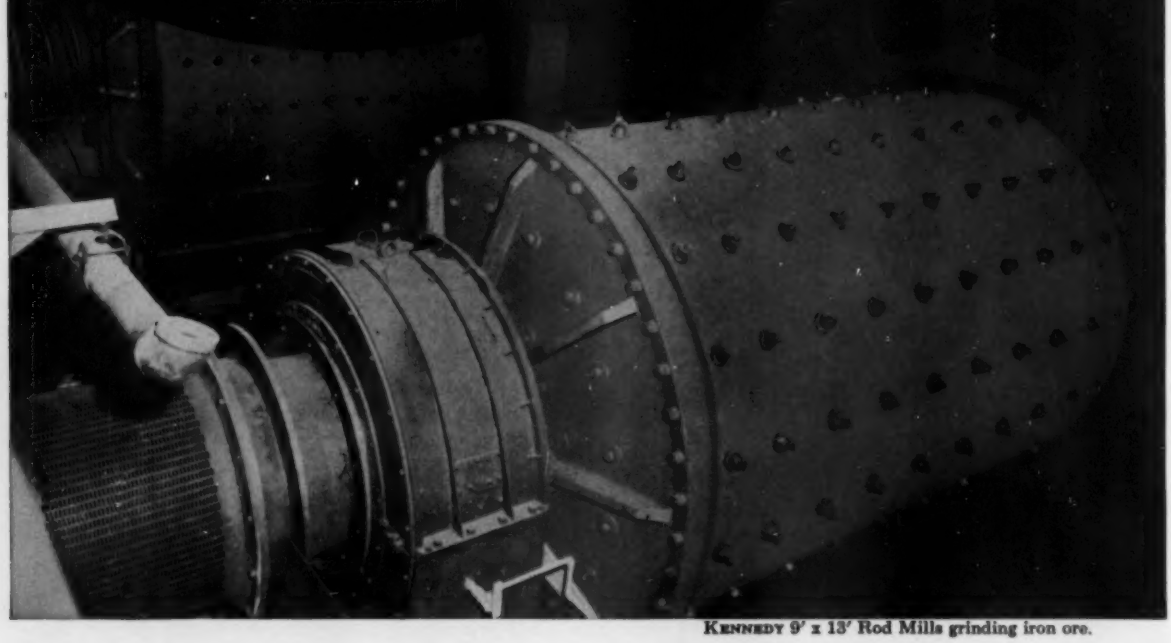

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BOOKS

Continued from page 926

Metalliferous Mine Surveying, by F. Winiberg, 4th Ed. revised by R.C.A. Hooper, *Mining Publications Ltd.*, 482 Salisbury House, London Wall, London E. C. 2, England, 399 pp., approx. $7.20, 1957.—Originally written as an amplified version of a lecture course on mine surveying given by the School of Metalliferous Mining, Cornwall, this fourth edition contains additions, replacements, and recent information either taken from the second and third editions or especially written for this book. The book covers methods and instruments suitable for the practice of metalliferous mine surveying in the field and underground. • • •

Papers and Discussions, 1954-1955, of the Association of Mine Managers of South Africa, *The Transvaal and Orange Free State Chamber of Mines,* P.O. Box 809, Johannesburg, Union of South Africa, 770 pp., 1956. —After a general chapter on recent developments in gold mining practice in South Africa, the articles in this book cover specific topics and companies in papers written for presentation at association meetings. Book was printed for private circulation. A copy is available in New York Public Library.

The Chemical Industry Facts Book, 3rd Ed., published by the *Manufacturing Chemists' Assn. Inc.*, 1625 Eye St., N.W., Washington 6, D. C., 141 pp., $1.25, 1957.—A basic reference work on the chemical industry, this book contains 15 chapters ranging from general topics such as industry's role in the economy to specific ones such as chemicals and nuclear energy. This new edition updates information on many facets of the industry. There are numerous charts, graphs, and tables.

Analytic Kinematics of Plane Motion Mechanisms, by Jesse Huckert, *The MacMillan Co.*, 209 pp., $7.75, 1958.—The author, who is associated with the Jeffrey Manufacturing Co., has designed a basic textbook on motion for student engineers. It is intended to supply a sound scientific understanding of the vectors of motion, and to clarify unreliable notions and half truths students may have on the subject. • • •

Surface Active Agents and Detergents, Vol. 2, by Anthony M. Schwartz and others, *Interscience Publishers Inc.*, 250 Fifth Ave., New York 1, N. Y., 839 pp., $17.50, 1958.—This volume supplements the material covered in Vol. 1 and covers developments during the period 1947 through 1956. Various sections deal with processes for synthesizing and

(Continued on page 933)

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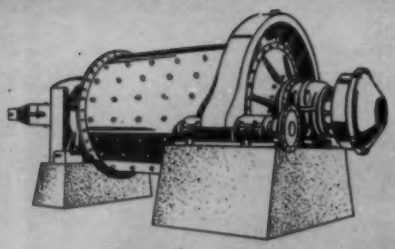
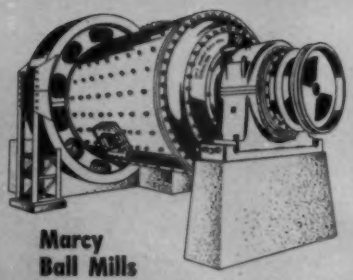


Marcy Rod Mills



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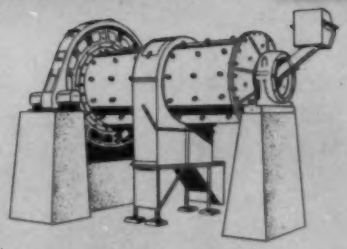

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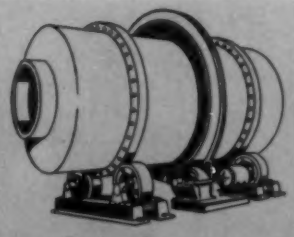

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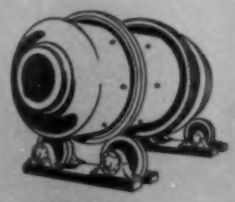

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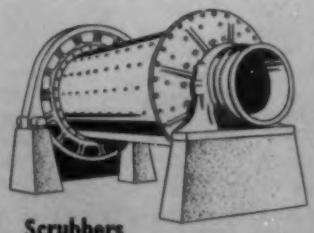
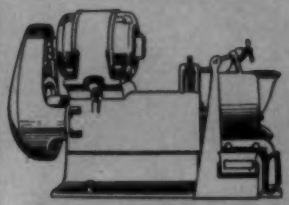


Scrubbers



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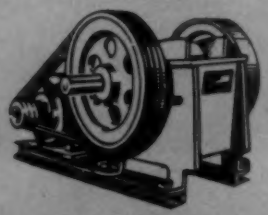

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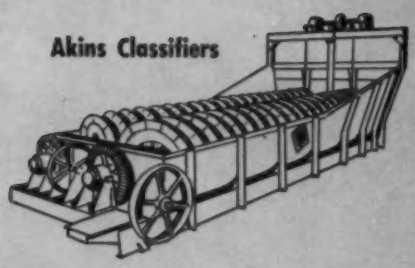
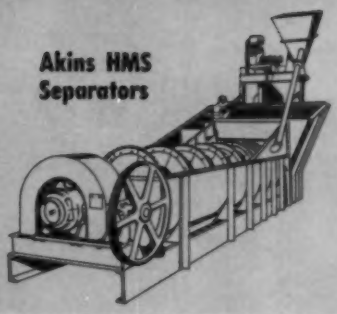
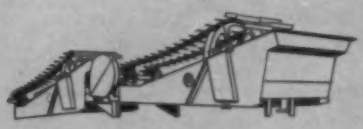


Akins Classifiers



Akins HMS Separators

Akins Densifiers



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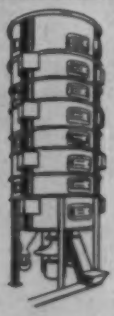
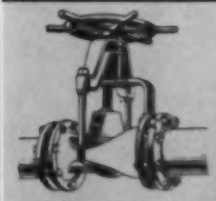
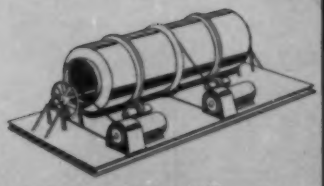


Wilfley Tables



Massco-Grigsby Rubber Pinch Valves

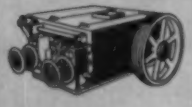
Marcy Pulp Density Scale



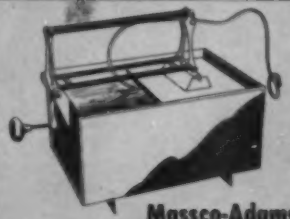
Pug Mills

Vezin Sampler

Massco Gy-Roll Reduction Crusher



Lab Crushing Rolls



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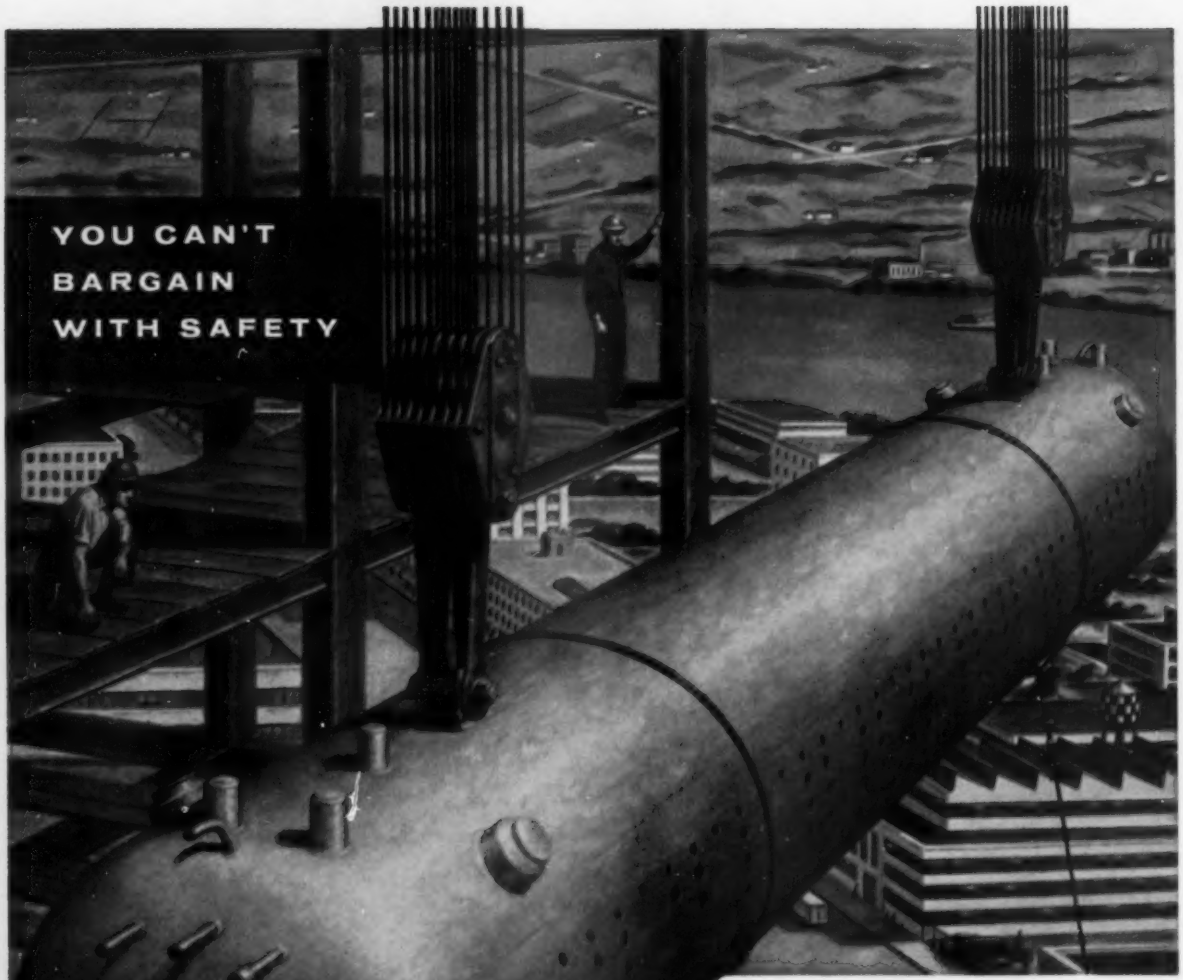

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BOOKS

Continued from page 929

manufacturing surfactants, special function surfactants and compositions, the physical and colloidal chemistry of surfactants, and the practical applications of surfactants. • • •

Pioneering in Industrial Research, by Kendall Birr, *Public Affairs Press,* 419 New Jersey Ave. S.E., Washington, D. C., 204 pp., $4.50, 1957.—The book tells the story of the General Electric Co.'s research laboratory, its founding and the famous scientists who have been associated with it throughout its history. The development of the laboratory from its inception to its present-day eminence in the field, is also covered. • • •

Graphic Methods in Structural Geology, by William A. Donn and John A. Shimer, *Appleton-Century-Crofts Inc.,* 35 W. 32nd St., New York 1, N. Y., 192 pp., $4.00, 1958.—This book attempts to provide a useful and fairly complete discussion of the common graphic procedures used for solving problems in structural geology. Although written primarily for the undergraduate student, it may also provide a convenient reference for the graduate student as well as the professional geologist. • • •

The Metallurgy of Vanadium, by William Rostoker, *John Wiley & Sons Inc.,* 185 pp. $8.50, 1958.—This book records the progress made in the state of knowledge of alloying and physical and mechanical properties of vanadium. In addition, the groundwork for future investigations into the potential usefulness of vanadium is laid. The book gathers together scattered papers in the technical literature, plus reports of research by the Armour Research Foundation sponsored by the Materials Laboratory of the Wright Air Development Center. • • •

Statistical Summary of the Mineral Industry (Production, Exports and Imports) 1951-1956, prepared by Mineral Resources Div., *Overseas Geological Surveys,* Her Majesty's Stationery Office, London, England, 371 pp., $3.90 approx., 1958.—An annual publication of statistical tables covering a period of six years showing world production, exports, and imports of all the important economic minerals and metals. • • •

State Publications

Geology and Ground-Water Resources of Madison County, Alabama, by Glenn T. Malmberg and H. T. Downing, County Report 2, U. S. Geological Survey in cooperation with City of Huntsville and *Geological Survey of Alabama,* P.O. Drawer O, University, Ala., 225 pp. plus maps and illustrations, $1.00 postpaid, 1957.

A Preliminary Geological Map of Connecticut, by John Rodgers, Robert M. Gates, Eugene N. Cameron, and Reuben J. Ross, Jr., *Geological and Natural History Survey of Connecticut,* write to Robert C. Sale, State Librarian, State Library, Hartford 15, Conn., 25¢ mailed to Connecticut residents; 50¢ to nonresidents.

Twenty-Seventh Biennial Report of the Commissioners of the Survey, 1955-1956, *Geological and Natural History Survey of Connecticut,* write to Robert C. Sale, State Librarian, State Library, Hartford 15, Conn., 20¢, 1956.

Geology and Ground-Water Resources of Highlands County, Florida, Report of Investigations No. 18, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., 115 pp., 12 figs., 11 tabs., 1 copy gratis, additional copies $1.50, 1956.

A New Species of Osteoborus from the Bone Valley Formation of Florida, Special Publication No. 2, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., 4 pp., first copy gratis, additional copies $1.50, 1956.

Interim Report on Surface-Water Resources and Quality of Waters in Lee County, Florida, Information Circular No. 7, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., 69 pp., 9 figs., 3 tables, first copy gratis, additional copies $1.50, 1956.

Interim Report on Ground-Water Resources of the Northeastern Part of Volusia County, Florida, Information Circular No. 8, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., 68 pp., 14 figs., 4 tables, first copy gratis, additional copies $1.50, 1956.

Interim Report on Salt-Water Encroachment in Dade County, Florida, Information Circular No. 9, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., 5 pp., 12 figs., first copy gratis, additional copies $1.50, 1957.

Mineral Resources and Industries of Florida, by James L. Calver, *Florida Geological Survey,* P.O. Box 631, Tallahassee, Fla., map 10x14 in., scale 45 miles per in., first copy gratis, additional copies $1.50.

Gypsum and Anhydrite, Fluospar for Controlling Vanadium Staining, Capsule Reports, Illinois Industrial Minerals Notes No. 5, by J. C. Bradbury and J. W. Baxter, *Illinois State Geological Survey,* Urbana, Ill., 9 pp., gratis, 1957.

Trend in Fuel Uses in Selected Industrial Mineral Products, 1947 and 1954, Illinois Industrial Minerals Notes No. 6, by W. H. Voskuil, *Illinois State Geological Survey,* Urbana, Ill., 4 pp., gratis, 1957.

Outlying Occurrences of Galena, Sphalerite, and Fluorite in Illinois, Illinois Industrial Minerals Notes No. 7, by J. C. Bradbury, *Illinois State Geological Survey,* Urbana, Ill., 5 pp., gratis, 1957.

Shipping Coal Mines Map of Illinois, *Illinois State Geological Survey,* Urbana, Ill., 30x51 in., 35¢, 1947 edition.

Pressure Losses Through Forced-Air Perimeter Fittings and Supply Outlets, Bulletin 440, by M. V. R. Rao, Donald R. Bahnfleth, and Herbert T. Gilkey, write to E. C. McClintock, Director, Technical Information and Publications, *University of Illinois,* 114 Civil Engineering Hall, Urbana, Ill., $1, 1958.

Hydraulic Fracture Theory, Part I—Mechanics of Materials, Circular 251, by James M. Cleary, *Illinois State Geological Survey,* Urbana, Ill., 24 pp., 12 figs., gratis, 1958.

Hydraulic Fracture Theory, Part II—Fracture Orientation and Possibility of Fracture Control, Circular 252, by James M. Cleary, *Illinois State Geological Survey,* Urbana, Ill., 20 pp., 3 figs., gratis, 1958.

Preliminary Coal Map No. 7, by Charles E. Weir, *Indiana Geological Survey,* Publications Section, Geological Survey, Indiana Dept. of Conservation, Indiana Unversity, Bloomington, Ind., 50¢, 1958.

The Mineral Industry of Indiana, by Donald F. Klyce and John B. Patton, reprint from Bureau of Mines Minerals Yearbook, *Indiana Geological Survey,* Publications Section, Geological Survey, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., gratis, 1955.

Rapid Conversion of Anhydrite to Gypsum, by R. K. Leininger, Robert F. Conley, and Wayne M. Bundy, reprint from Industrial and Engineering Chemistry, vol. 49, pp. 818-821, *Indiana Geological Survey,* Publications Section, Geological Survey, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 9 figs., 1 tab., gratis, 1957.

Early Pleistocene Sediments in Indiana, by William J. Wayne, reprint from The Journal of Geology, vol. 66, no. 1, pp. 8-15, *Indiana Geological Survey,* Publications Section, Geological Survey, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 8 pp., 1 plate, 1 fig., 1 tab., gratis, 1958.

Marginal Zones of Vanished Glaciers Reconstructed from the Preconsolidation-Pressure Values of Overridden Silts, by W. Harrison, reprint from The Journal of Geology, vol. 66, no. 1, pp. 72-95, *Indiana Geological Survey,* Publications Section, Geological Survey, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 9 pp., 8 figs., 1 tab., gratis, 1958.

Geology and Ground-Water Resources of Webster County, Iowa, Water-Supply Bulletin No. 4, by William E. Hale, *Iowa Geological Survey,* State Mine Inspector's Office, State Capitol, Des Moines, Iowa, 257 pp., 16 plates, 29 figs., 12 tabs., gratis except for out-of-state postage, 1955.

Quality of Surface Waters of Iowa, 1886-1954, Water-Supply Bulletin No. 5, prepared under the direction of V. R. Bennion, *Iowa Geological Survey,* State Mine Inspector's Office, State Capitol, Des Moines, Iowa, 351 pp., 4 plates, 19 figs., 13 tabs., gratis except for out-of-state postage, 1955.

Report of the State Mine Inspectors for the Biennial Period Ending December 31, 1955, *State of Iowa,* State Mine Inspector's Office, State Capitol, Des Moines, Iowa, 24 pp., gratis, 1956.

The Mineral Industry in Kansas in 1956, Bulletin 127, Part 6, by Walter H. Schoewe, *State Geological Survey of Kansas,* University of Kansas, Lawrence, Kan., 52 pp., 3 figs., 41 tabs., 50¢, 1957.

Relationship of the Lansing Group and the Tonganoxie ("Stalnaker") Sandstone in South-Central Kansas, Bulletin 127, Part 4, by Richard L. Winchell, *State Geological Survey of Kansas,* University of Kansas, Lawrence, Kan., 30 pp., 3 plates, 4 figs., 3 separate maps, 25¢, 1957.

Report of the Mine Inspection Section and the Mine Rescue Station From January 1, 1954 to June 30, 1956, Labor Dept., *State of Kansas,* John Delplace, Chief Mine Inspector, College Post Office, Pittsburgh, Kan., 122 pp., gratis, 1956.

Review of Geophysical Activity in Kansas Through 1956, by William W. Hambleton and Daniel F. Merriam, *State Geological Survey of Kansas,* University of Kansas, Lawrence, Kan., 24 pp., 2 figs., 25¢, 1957.

Cornetsville Quadrangle (parts of Perry, Knott, Letcher, Harlan, and Leslie Counties), USGS C-22, by Johnson, Stafford, and Welch, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., $1.00 plus 10¢ postage, 1955.

Seitz Quadrangle (parts of Breathitt, Magoffin, Morgan, and Wolfe Counties), USGS-OM 173, by M. J. Bergin, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., 50¢ plus 10¢ postage, 1955.

Tiptop Quadrangle (parts of Breathitt, Magoffin, and Knott Counties), USGS-OM 163, by S. W. Welch, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., 50¢ plus 10¢ postage, 1955.

Mineral Resources Summary for Kentucky 1953 and 1954, RI 10, by Preston McGrain and R. J. Floyd, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., 75¢ plus 10¢ postage, 1956.

Recent Investigations of Silica Sands of Kentucky No. 2, RI 11, by Preston McGrain, *Kentucky Geological Survey* and the *Kentucky Dept. of Economic Development,* address Kentucky Geological Survey, 120 Graham Ave., Lexington, Ky., 50¢ plus 10¢ postage, 1956.

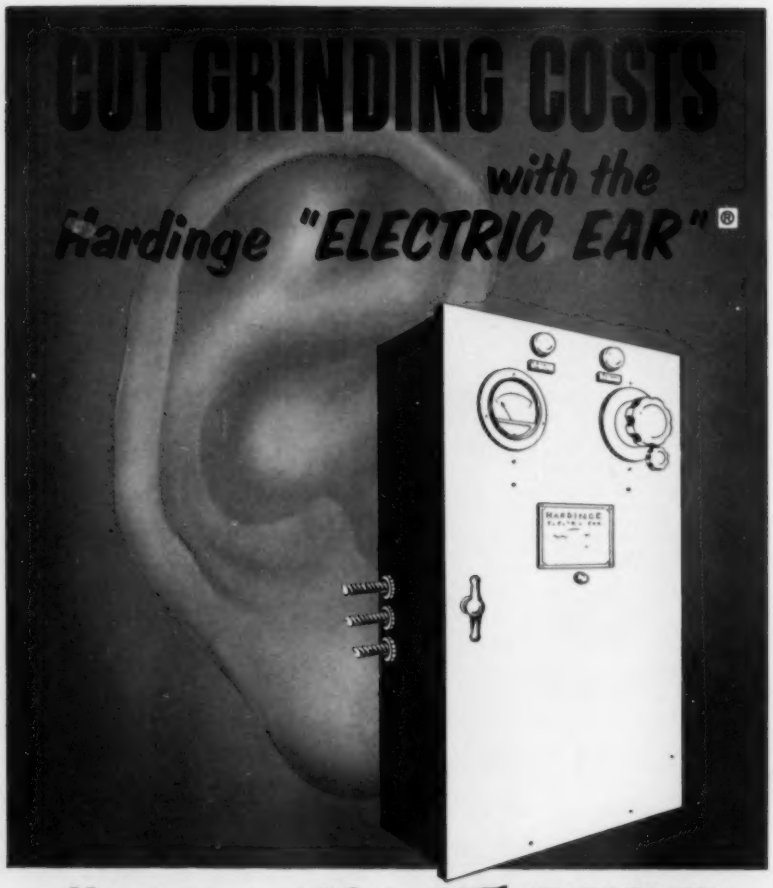
Sources of Shale in Kentucky for Lightweight Aggregate Production, RI 12, by Preston McGrain, *Kentucky Geological Survey* and the *Kentucky Dept. of Economic Development,* address Kentucky Geological Survey, 120 Graham Ave., Lexington, Ky., 50¢ plus 10¢ postage, 1957.

Sources of Fuller's-Earth Type Clay in Kentucky, IC 6, by Preston McGrain, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., 10¢ postage, 1956.

A Study of Magnetic Anomalies Associated with Ultrabasic Dikes in the Western Kentucky Fluorspar District, Bulletin 19, by J. R. Warren, *Kentucky Geological Survey,* 120 Graham Ave., Lexington, Ky., 75¢ plus 10¢ postage, 1956.

Some Old Chester Problems—Correlations Along the Eastern Belt of Outcrop, Bulletin

(Continued on page 934)



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BOOKS

Continued from page 933

20, by A. C. McFarlan and F. H. Walker, *Kentucky Geological Survey*, 120 Graham Ave., Lexington, Ky., 75¢ plus 10¢ postage 1956.

The Petrography of Certain Igneous Dikes of Kentucky, Bulletin 21, by James B. Koenig, *Kentucky Geological Survey*, 120 Graham Ave., Lexington, Ky., 75¢ plus 10¢ postage 1956.

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Request free publications from:

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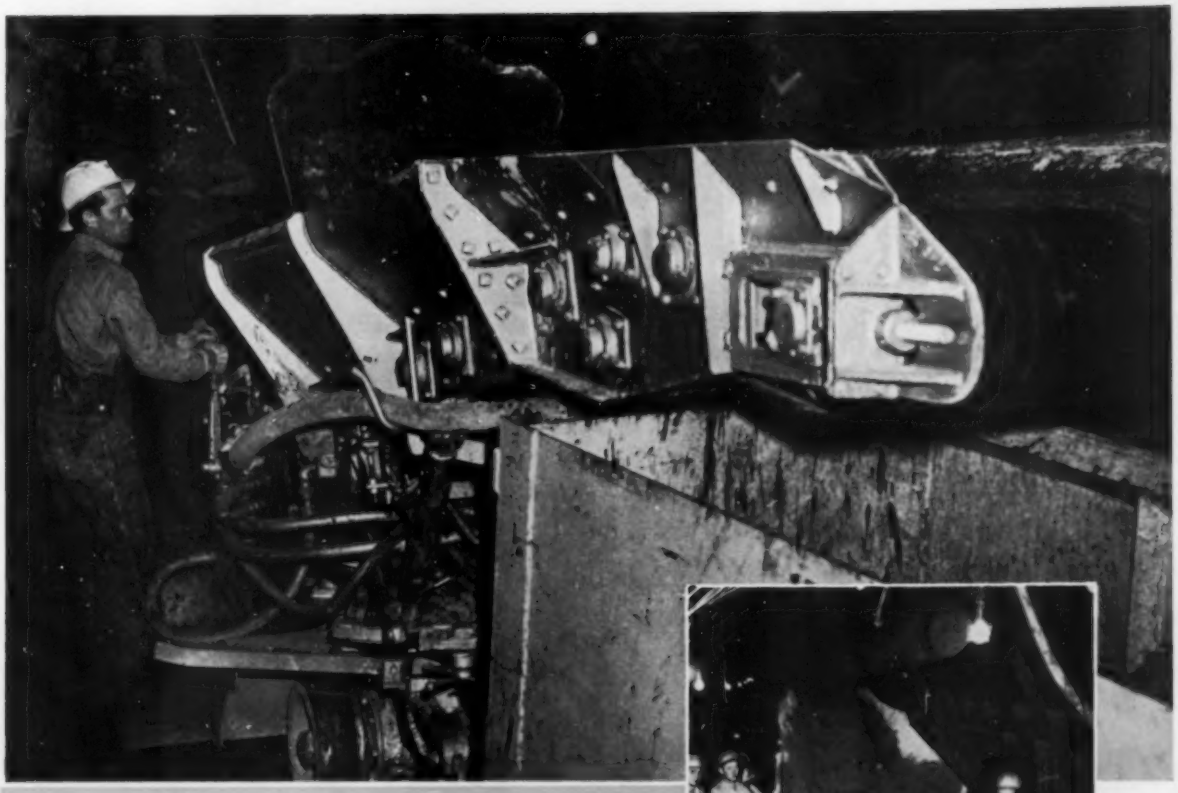
Multiple Use on Mining Claims, 10¢.
37L Analysis of Research in the Teaching of Science, July 1955-July 1956, 55 pp., Catalog No. FS 5.3:958/7, 25¢, 1958.
38L Education Directories, 1957-58, Part 1. Federal Government and States, 70 pp., Catalog No. FS 5.25:957-58/pt.1, 30¢, 1958.
39L Education Directories, 1957-58, Part 2. Counties and Cities, 101 pp., Catalog No. FS 5.25:957-58/pt.2, 45¢, 1958.
40L Education Directories, 1957-58, Part 3, Higher Education, 190 pp., Catalog No. FS 5.25:957-58/pt.3, 65¢, 1958.
45L Selected Annotated Bibliography of Asbestos Resources in the United States and Canada, pp. 817-865, Catalog No. I 19.3:1019-L, 25¢, 1958.

Minerals Yearbook 1955, Vol. I, Metals and Minerals (Except Fuels), prepared by Div. of Minerals Staff, *U. S. Bureau of Mines*, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1366 pp., $4.25, 1958.—Data includes chapters on metal and nonmetal mineral commodities, a review of these mineral industries, a statistical summary, and chapters on technology, employment, and injuries. The data are based upon information supplied by mineral producers, processors, and users compiled by the USBM. • • •

Minerals Yearbook 1955, Vol. III, Area Reports, prepared by Field Staff, *U. S. Bureau of Mines*, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1228 pp., $4, 1958.—Data includes that collected by USBM and by State and Territorial agencies. Vol. III is comprised of chapters covering the 49 States plus Territory of Hawaii, and possessions. Also included are a statistical summary chapter, identical with that in Vol. I, and another presenting unemployment and injury data. • • •

For information on Minerals Yearbook 1954, Vols. I through III, see the May issue, page 534.



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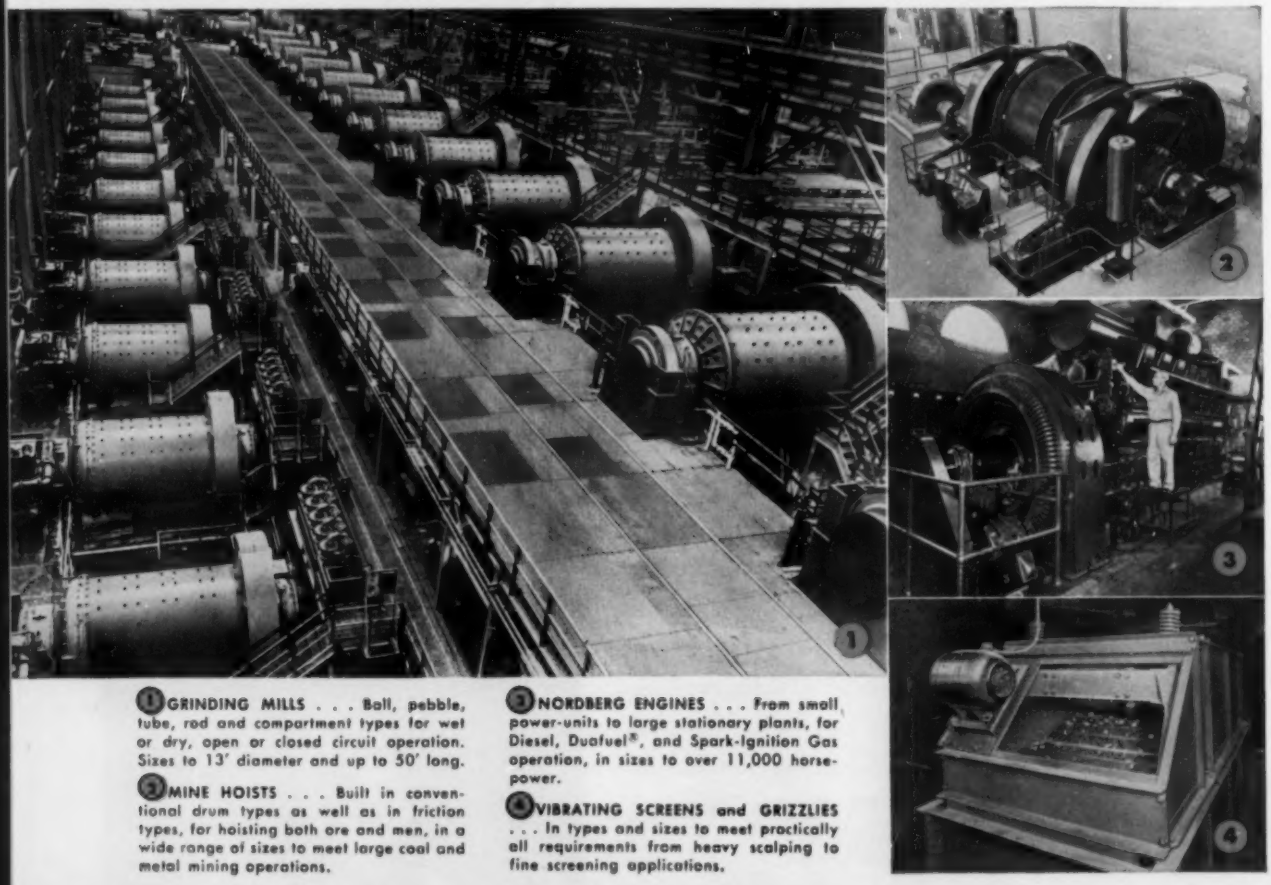

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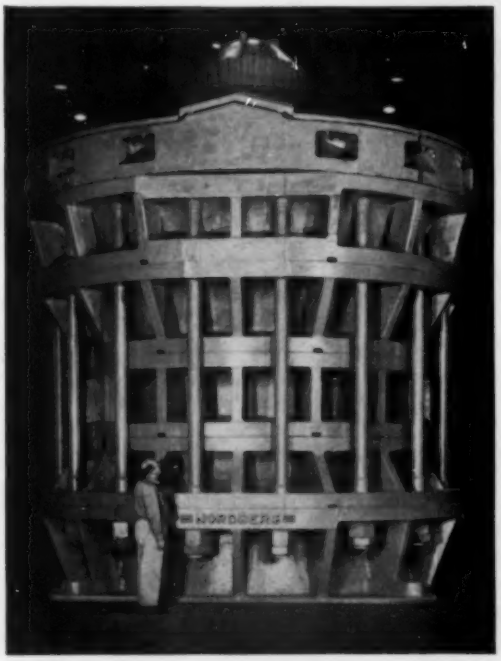
Built in 11 different sizes, ranging from 22" to 7' dia., for capacities from 6 to 900 or more tons per hour.

(Illustrated at the right is a typical installation of Symons Cone Crushers and Rod Deck Screens serving a large Taconite Iron Ore producer).



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For heavy-duty primary breaking, available with feed opening sizes of 30", 42", 48", 54", 60" and 72", for capacities to 3,500 and more tons per hour.

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M158

***See** the Nordberg Exhibit at the big 1958 Mining Show in San Francisco!*

Q: WHICH D7 IS THE OLD-TIMER?

This Cat D7 Tractor with No. 7S Bulldozer feeds the grizzly about 450 tons of gold ore a day.

This Cat D7 Tractor with No. 7S Bulldozer, working in heavy wet sand, is building a 2-mile-long dike.

A: If you know your Cat Diesel Tractors, you've spotted it on the left. It's 12 years old. With the new D7 and a D8, it's used by the London Extension Mining Co. in an open pit mining operation 30 miles from Beowave, Nevada. The climate's rugged. Temperatures range from −20° to 110°.

Q: What does the company think of the machines?

A: It has had Caterpillar-built equipment since 1936. General Superintendent R. B. Warmbrodt says: "We find the tractors are rugged and stand up well."

Q: How are the machines used?

A: Generally one is kept in the pit cleaning up around shovels, while the other feeds the grizzly 450 tons of ore a day. The machines also strip overburden, handle tailings and knock down dump piles from trucks at the stockpile. Two months a year, the new D7 builds about 2 miles of dike to control tailings. The machines are on duty 7 days a week all year 'round.

Q: How do the D7s compare in production?

A: Good as the old D7 is, it's not in the same league with the modern, heavy-duty D7. Of course, that's to be expected. Caterpillar constantly builds improvements into its machines. The new D7 is more powerful, easier to operate and more rugged. For example, among many modern features, it has the oil clutch that delivers 1,500 hours without adjustment.

Q: Has the company any other Caterpillar equipment?

A: Yes. Two engines in shovels and two in compressors. Mr. Warmbrodt says: "Since we're far from supply, we find the parts interchangeability of Caterpillar units a decided advantage. We also get excellent service from our Caterpillar Dealer!"

Add all this up and you get some of many reasons why it will pay you to use a Cat Diesel Tractor on your operation. You can't beat the combination of rugged machines, parts availability and good dealer service. Ask your Caterpillar Dealer to give you the low-down on the new D7's high productive capacity. Better still, watch one work —ask him to demonstrate on your job!

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MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

Radio Detector

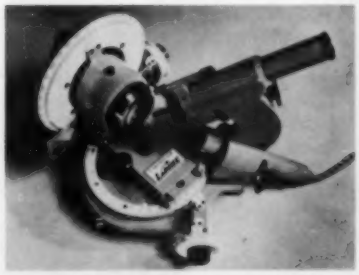
Geophysicists may find use for a transistorized astronomical amplifier developed by *MF Electronics Co.* The device is a detector operating from a radio tuned to WWV, the standard broadcast signal. It energizes a relay in synchronism with time pulses from this station. Two additional channels may be used to energize relays upon momentary closure or opening of contacts attached to the respective inputs. This enables accurate comparison of any events as a function of time, against the mean time broadcast by the WWV transmission. **Circle No. 1.**

Chelating Agent

Imperial CM, a chelating sequestering agent of botanical origin, developed by *Imperial Chemicals Corp.* has a two-fold purpose: It raises the grade of concentrate and inhibits scale deposit in mill circuits. Chelating and sequestering power is claimed about seven times as strong as that of any other known chelating agent, and it remains stable at temperatures up to boiling at any pH above 4.2. **Circle No. 2.**

Goniometer

Mineralogists and chemists can identify crystalline substances by simple external measurements of interfacial angles with a new inexpensive optical goniometer available through *Arthur S. LaPine & Co.* Designated the Techne CM Two-Circle goniometer, the unit can eliminate chemical analysis and destruction of specimens. The method is used in conjunction with the Barker Index of Crystals. **Circle No. 3.**

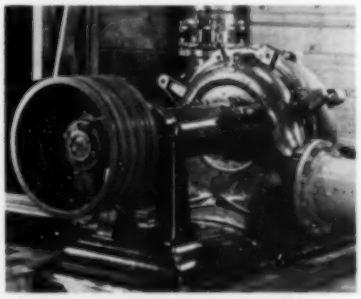


Vibratory Feeder

Syntron Co.'s new model F-010 electromagnetic vibratory feeder offers high-capacity, rate-controlled feeding of bulk materials. Rheostat control affords immediate adjustment of feed rate to a maximum of 3 tph. Standard flat pan trough measures 5x24 in. **Circle No. 4.**

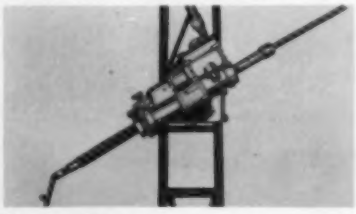
Centrifugal Pump

Demand for higher tonnages has led *A. R. Wilfley & Sons Inc.* to introduce a new 10-in. slurry pump. An addition to the well-known model K line, the new unit will be available with a selection of abrasion-resistant alloys and interchangeable soft-rubber covered wear parts. Construction is rugged and parts replacement is easy. **Circle No. 5.**



Underground Diamond Drill

Joy Mfg. Co. has a new diamond core and blasthole drill designed to operate at full motor power for extremely high torque at lower bit speeds. Designated the Joy 25, the drill has a 14-hp rotary air motor and is rated at up to 500 ft of AX or 625 ft of EX hole. **Circle No. 6.**



Bottom Dump

Caterpillar Tractor Co.'s DW20 tractor and *Athey Products Corp.'s* PW20 bottom dump trailer make a combination capable of hauling a 40-ton payload at speeds up to 35 mph. The trailer, made entirely of T-1 steel, has almost a four to one ratio of vehicle weight to payload. Side plates are steeply angled, bottom doors are large, and the exclusive rear third door permits clean, quick dumping. **Circle No. 7.**

Drill Rod Clamp

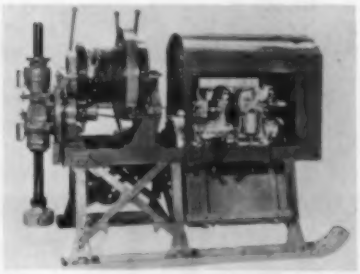
E. J. Longyear Co. has introduced a safety clamp designed to hold many sizes of diamond drill rods or casing with a single set of V-shaped, carbide-faced jaws. Jaws are faced with hundred of tungsten carbide particles and are shaped for firm gripping on all sizes within the range of the clamp. **Circle No. 8.**

Continuous Miner

Variable operating height suits a new boring type continuous miner by *Goodman Mfg. Co.* to work coal as low as 5½ ft or as high as 7½ ft. Machine is powered by a single 250-hp a-c or d-c motor and is rated at a capacity of 8 tons per min. Roof bolting drills can be supplied for attachment to the machine to permit bolting ahead of the operator. Unit design emphasizes accessibility for adjustment and maintenance. **Circle No. 9.**

Surface Diamond Drill

The improved Boyles model BBS-2 diamond drill by *Boyles Bros. Drilling Co.* features a Hercules engine delivering 88 hp at 3200 rpm. Fuel economy and interchangeability between diesel and gas units are offered. Drill, capable of depths to 3500 ft, offers a wide range of swivel head types. **Circle No. 10.**



Vibrating Screen

Allis-Chalmers has added a 7-ft wide Ripl-Flo unit to its line of vibrating screens. Added screening output with a minimum increase in required floor space is featured and users will find less auxiliary equipment is needed. **Circle No. 11.**

See something modern, something new for

Mine, Mill & Laboratory

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1958

Mining

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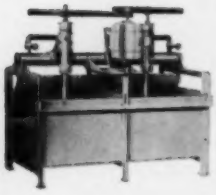
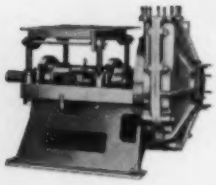


AGITAIR®

Flotation Machine renowned throughout the world for high recovery performance . . . low cost operation.

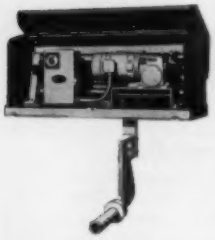
Operation models of each of these products will be displayed.



VACSEAL PUMPS

. . . a complete line of solids handling and acid pumps. Sizes 1½" to 8".

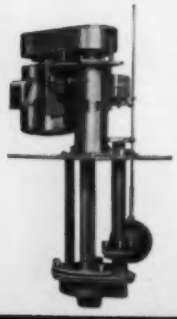
Samples exhibited of construction-materials and parts for all replaceable liner VACSEAL Pumps.



GEARY-JENNINGS SAMPLER

. . . accurate, automatic samples of practically all kinds of material.

Metallurgical engineers will be in attendance to explain Galigher products and services.



GALIGHER SUMP PUMP

available in acid-proof or standard construction. No seals, packing or submerged bearings. Sizes 1½" to 2½" — capacities 10 to 250 GPM.

See the new all plastic sump pump in operation.

AP-504

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GALIGHER PRODUCTS: AGITAIR® Flotation Machine, VACSEAL Pump, Geary-Jennings Sampler, Acid-proof Sump Pump, Geary Reagent Feeder, Laboratory AGITAIR® Flotation Machine, Laboratory Pressure Filter, Laboratory Ball Mill, Rubber Lined and Covered Products, Plastic Fabrication.

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EASTERN OFFICE: 921 Bergen Ave. (Room 1128), Jersey City 6, New Jersey

Cable Couplers

Plug-and-socket convenience for connecting portable cables rated up to 7500 v is available with new couplers by *PLM Products Inc.* Connections are completely enclosed and contacts are broken before threaded housings disengage. Complete coupler is 42 in. long and is available with heavy-duty sled base. Unit is rated at 300 amp. **Circle No. 12.**

Tournapull

Both horsepower and yardage capacity have been increased on the *LeTourneau-Westinghouse* model B Tournapull. Standard horsepower is now 335. Capacity is 21 cu yd struck, 28 yd heaped. **Circle No. 13.**

Explosives

New brand names for certain similar grades and types of high explosives have been assigned by the explosives and mining chemicals department of *American Cyanamid Co.* for easier identification by users. New Cyanamid names and former American and Illinois Powder names replaced are as follows:

NEW CYANAMID BRAND NAMES	FORMER ILLINOIS BRAND NAMES	FORMER AMERICAN BRAND NAMES
Straight Gelatin Pawertel Ajax Cyamite Cya-Gel-Pak CX Dynamites	N.G. Gelatin Pawertel Ajax Gomex Phlogel G.L. Dynamites	Straight Gelatin Amex Semi Gelatin Cyamite Cya-Gel-Pak CX Dynamites

News & Notes

Curtiss Wright Corp. has purchased the earthmover manufacturer, *Wooldridge Div.*, formerly owned by *Continental Copper & Steel Industries . . . Linde Co.* has on stream a new oxygen plant situated directly on the eastern end of the Mesabi Range to provide nearby supply to jet piercers . . . *Spencer Chemical Co.* has formed a subsidiary for foreign operations—*Spencer Chemical International Inc. . . . Dings Magnetic Separator Co.* has world rights for Coronatron electrostatic separator developed by *Quaker Oats Co. . . . Mine Safety Appliances Co.* is expanding its Technical Products Div. for nation-wide service . . . *Abbot A. Hanks Inc.* has broken ground for a new San Francisco

laboratory. The testing service firm expects completion of the large new building by November 1958.

(21) CYCLOIDAL BLOWERS: A new bulletin detailing a complete line of cycloidal blowers for vacuum service is available from *Roots-Connersville Blower*, division of Dresser Industries Inc. The booklet, VP-158, details design features and supplies technical data.

(22) BIG V-ENGINES: The *Nordberg Mfg. Co.* line of 4-cycle V-type engines is described in a new 18-page bulletin. The 12 or 16-cyl units operate as diesel, Duafuel, or spark-ignition gas engines and can be used for generating and pipeline applications, among others.

(23) ROPE BELT CONVEYOR: Latest design of the Limberope rope belt conveyor system by *Joy Mfg. Co.* is explained in new 2-page bulletin GG-6C. Idlers are swivel mounted to rigid cradle brackets for flexibility and load conformity while keeping wire rope support stringers parallel to avoid detraining.

(24) BENEFICIATION EQUIPMENT: Thickeners, agitators, conditioners, diaphragm pumps, and settling cones are all covered in bulletin 573 from *Morse Bros. Machinery Co.*

(25) PIPE JOINTS: A fast, economical leak-tight method of piping is detailed in catalog-manual 58 from *Victaulic Co. of America*. Standard, lightweight, and snap-joint couplings are specified for use in mines, mills, quarries, tunnels, dredging.

(26) DIAMOND BITS, CORE BARRELS: *Christensen Diamond Products Co.* is offering a 22-page brochure detailing diamond core bits, reaming shells, non-coring bits, casing shoes and bits, chrome-plated inner tubes, and a variety of core barrels. Prices are included with specifications.

(27) HAND HOISTS: Wright Safeway hand hoists in capacities from ½ to 50 tons are described in 8-page bulletin DH-164-C from *American Chain & Cable Co.*

FREE LITERATURE

(28) VIBRATING FEEDERS: Low horsepower and low stress design assures minimum maintenance and less downtime says *Carrier Conveyor Corp.* of its Natural-Frequency vibrating feeders. Eight-page bulletin 1001 supplies details.

(29) WIRE SCREENS: A complete catalog of Vibraloy and Vibraloy T woven wire Arc-Loc screens is offered by *Audubon Wire Cloth Corp.*

The company's modern facilities for wire drawing, tempering, and testing are also detailed.

(30) AGGREGATES: A 40-page book detailing methods of aggregate preparation, beneficiation, and handling is available from the Wemco Products Div. of *Western Machinery Co.* Bulletin G7-B25 is illustrated with charts, working drawings, and photos describing the use of Wemco equipment in the aggregate industry. Complete engineering data is given for ten Wemco machines used in aggregate production.

(31) DUST COLLECTOR: New 8-page bulletin C-958 from *Ducon Co. Inc.* illustrates and describes the company's cyclone dust collectors and gives information on four types of Ducon gas-tight, free-discharge valves for cyclones or storage hoppers.

(32) T-1 STEEL: *Lukens Steel Co.* claims you can cut costs on weight, fabrication, and on maintenance and replacement with the high-strength, readily welded alloy steel designated T-1. New 24-page form 781 shows how the steel is being used in material handling, mining, earth moving, and other industrial uses. Properties are covered thoroughly.

(33) RADIO EQUIPMENT: Bulletin ECR 576 from *General Electric's* Communication Products Dept. describes newly-announced FCC categories on industrial use of two-way radio and explains the types of equipment available. General Electric has three types ready for use: industrial in-plant equipment, transistorized portable equipment, and mobile radio with transistor power supplies.

(34) PUMPS & VALVES: *Allen-Sherman-Hoff Pump Co.* has two related pumping bulletins. Four-page brochure 857 illustrates the A-S-H packless rubber-lined pump, which has no stuffing box, no sealing device, and no exposed metal parts. Its two sizes handle abrasives and acids from 25 to 800 gpm. Brochure explains how A-S-H Flex-Check rubber-lined valves offer negligible resistance to flow but snap tight against back pressure.

(35) DOZERS: Three bulletins from *J. I. Case Co.* supply data on three models of Case Terratrac crawler-mounted dozers. Model 320 is gasoline-powered, uses 42 hp; model 500 has torque converter drive and offers choice of gasoline or diesel power; model 600 features torque converter and hydraulic transmission, 62 hp.

mail this post card for more information

9

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Dec. 15, 1958—if mailed in U. S. or Canada

Please send { More Information ☐ Price Data ☐ Free Literature ☐ } on items circled.

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61	62	63	64						

Students should write direct to manufacturer.

(36) MOTOR GRADERS: "Command Performance" from *Caterpillar Tractor Co.* is a new booklet featuring the components of Cat-built motor graders.

(37) STEEL BUILDINGS: Bulletin K-90 from Truscon Steel Div. of *Republic Steel Corp.* supplies 24 pages of planning data and illustrations of the Truscon standardized steel buildings for industry. Appearance, strength, and permanence are featured in these building products which cover all structural needs.

(38) LOADING ASSEMBLIES: No-leak piping devices for loading and unloading liquid storage tanks and tank cars are detailed in new 24-page catalog F-32R from Jordan Industrial Sales Div., *OPW Corp.*

(39) PARTICLE SIZE ANALYZER: Four-page bulletin 0708-1 by *Mine Safety Appliances Co.* gives details on a low-cost, general purpose instrument for 0.1 to 40 μ particles.

(40) SMALL TRANSIT: The Eagle 4-in. transit is a lightweight unit selling for $290 and available from *Texas-Asiatic Import Co.*

(41) CAST IRON PULLEYS: Jones Machinery Div. of *Hewitt-Robins Inc.* has a 16-page catalog listing the company's standard cast iron pulleys and accessories. Prices are included.

(42) DIESEL ENGINES: Two new diesel engines, models D-344 and D-516, recently added to the power unit line of *Allis Chalmers Mfg. Co.* are described in 16-page catalog BU-413.

(43) FIRE EXTINGUISHER SAFETY: A handbook of safety codes from the *Fire Eqpt. Mfr.'s Assn. Inc.* has 42 pages of procedures for maintaining, protecting, recharging, and inspecting fire extinguishing equipment. Methods assure long life and efficient service from portable units, carbon dioxide systems, standpipe and inside hose systems, and fixed foam systems.

(44) SELF-LOCKING NUTS & BOLTS: Two brochures from *Republic Steel* show how nylon-insert Nylok fasteners assure positive lock and a tight vibration-proof seal. The reusable fasteners are detailed in two folders: bolts, form 792; nuts, form ADV-697.

(45) BENEFICIATION EQUIPMENT: *Galigher Co.* has a data sheet covering the low-cost Conditioner and the Tilting Filter.

(46) HIGHWAY TRUCK TIRES: Service is the theme of *B. F. Goodrich Tire Co.'s* new highway truck tire data book. Its 42 pages cover the complete B. F. Goodrich line and

detail tire selection, mileage booster plan, inflation, loads and their distribution, mechanical irregularities, matching and spacing duals, tire rotation, rims, and retread before failure.

(47) TUBULAR PRODUCTS: Information on the application of tubing, pipe, fittings, and flanges in the process industries is supplied in 16-page booklet TB-417 from the Tubular Products Div., *Babcock & Wilcox Co.*

(48) CONTROLLED SPEED SYSTEMS: An 8-page booklet from *U. S. Electrical Motors Inc.* describes typical installations for controlled automatic variable speed systems application. Systems can be used in basic handling processes such as mixing, filtering, conveying, proportioning. Ask for booklet F-1952.

(49) PLYWOOD-MOLDED PIPE: *Plycraft Inc.* has developed a plywood-molded pipe that can be produced economically in any diameter and lined to suit your needs. Weight and ease of handling are plus features.

(50) MECHANICAL DRAFT FANS: Bulletin FMD-101 describes *Chicago Blower Corp.* forward curve mechanical draft fans ranging in size from 18 to 80 in.

(51) DIESEL TRACTOR: The International TD-18 tractor is detailed in 16-page form CR-631-H from *International Harvester Co.*, Construction Eqpt. Div.

(52) RUBBER JOINTS & PIPE: *General Rubber Corp.* offers a complete line of rubber expansion joints and flexible pipe for pressure and vacuum systems handling water, brine, gases, and chemicals.

(53) CONTINUOUS FILTER: More filter surface and foam-borne solids removal are features of the self-cleaning Delpark dual manifold filter by *Industrial Filtration Co.* Unit is especially suited for filtration of water from wet type dust collectors and other liquids with high solids content.

(54) COMPRESSOR: Bulletin PD-57 from *Schramm Inc.* describes the 125-cfm Pneumadiesel. Unit is available on skid or two-wheel mountings and is claimed to be 300 lb lighter than average diesel competitor.

(55) STEEL TUBING: An 8-page brochure describing mill grooved light weight steel tubing for use as portable pipe line with standard mechanical couplings is available from the Steel & Tubes Div. of *Republic Steel Corp.* System can be set up and broken down in a matter of minutes.

(56) ROD & BALL MILLS: Bulletin 575 from *Morse Bros. Machinery Co.* gives eight pages of details on a variety of rod and ball mills. Tabular data covers capacities and various charges.

(57) TREAD-MOUNTED LOADERS: Catalog G-134 from *Goodman Mfg. Co.* supplies data on the 900 series tread-mounted ac or dc loaders for coal, gypsum, or potash. Units mount four 20-hp motors, two each for loading and tramming—all are interchangeable.

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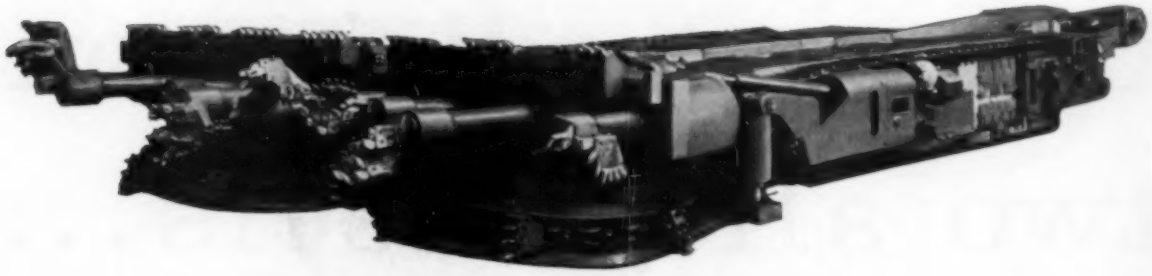
MINING ENGINEERING

29 WEST 39th STREET

NEW YORK 18, N. Y.

Makes a cut 14′7″ wide

All the benefits of fast, efficient, continuous mining... in seams as low as 28 inches



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Low maintenance

Jeffrey 86-A "Colmol" is only 25¼-inches high... mines seams as low as 28 inches... makes a cut 14-feet 7-inches wide... gives good cleanup and smooth bottom.

Specially designed cutting and gathering chain carries coal to the center of Colmol, then up and onto the swinging discharge conveyor. It smooths off the cusps, even when the breaker-arm head is raised 8 inches for maximum mining height.

This powerful, compact Colmol advances with minimum maneuvering. Coal is broken from the face... not ripped or ground off. You get good overall screen consist, greater speed and efficiency. Colmol withstands the most severe mining conditions, operates with little noise or vibration.

All adjustments are hydraulic, can be made instantly and accurately. Easily accessible parts simplify adjustment and servicing. Safety features provide extra protection for both personnel and machine.

For low seams... or seams up to 8 feet high efficient, easy-going Jeffrey Colmols step up your production rate, cut operating and maintenance costs. Write for full details. The Jeffrey Manufacturing Company, 365 North Fourth Street, Columbus 16, Ohio.

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Metal users, you can simplify... you can save money by standardizing on two alloy steels...

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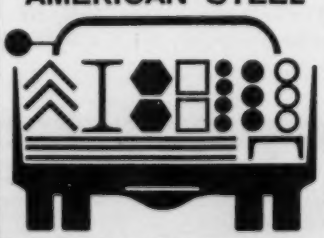


WAREHOUSE ASS'N.

Standardize on AISI 4620 and 4340 and you standardize on fabricating and heat treating processes...

Simplify inventory and purchasing...

Save money by cutting production costs right down the line...

You standardize, simplify and save money when you use AISI 4620 and 4340...available coast-to-coast from Steel Service Centers. For a list of these sources write:

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO **New York 5, N. Y.**

MINING engineering REPORTER

Price Trends

Steel. Steel's price was pushed upward about $4.25 a ton on certain mill products in a move that producers said reflected the July 1 wage increases stemming from a long-term union contract. Not a blanket upstep, the rise was placed selectively on certain items, contrary to past procedure. Moreover, the rise was started by Armco Steel—not U. S. Steel, the traditional market leader. Meanwhile, steel production continued its recent slow advance.

Aluminum. With a 0.7¢-a-pound increase in the price of aluminum, producers have started to gnaw at the 2¢ decrease unwillingly instituted last April. Aluminum Co. of America led off with the cut and soon was followed by other major producers. Canada's huge Aluminium Ltd., which initiated the April slash, dropped its U. S. prices in line with domestic firms but made no changes elsewhere. Producers cited higher employment costs, some claiming the increase was not enough to cover these expenses. The move was in obvious variance with Aluminium which was apparently indicating it was in no postion to raise prices when it made its recent announcement of a 10 pct reduction in output starting August 1.

Nickel. International Nickel Co. of Canada told stockholders recently: "The production of nickel was the Company's primary task during World War II and the subsequent period of emergency. Today, our principal task is the *marketing of nickel.*" The marketing problem is a big one, with huge stocks already accumulated. Inco announced its third output cut, effective July 14, and thus brought its annual rate to 200 million lb—down from its 250 million lb a year previously. The recent slash trimmed another 20 pct from Sudbury production. Price of 75 pct nickel oxide was also changed July 14—from 70.25¢ per pound of contained nickel, unpacked, f.o.b. Copper Cliff, Ont., to 69.60¢, packaged, f.o.b. Buffalo, N. Y.—to adjust "to a basis equivalent to that of the Cuban nickel oxides produced and sold by the U. S. Government."

Copper. A week-kneed rise in the price of copper finds both major producers and custom smelters quoting 26½¢ a pound. Improved conditions have induced Kennecott to step up its work week to five days from four days at the Chino, Utah, Nevada, and Ray mining divisions.

Twenty-Three Votes Kill Minerals Bill

After a session of last-minute amendments that greatly weakened the Administration's minerals subsidy bill, the House defeated the proposal with a vote of 182 to 159. The added amendments stripped the bill of aid for acid-grade fluorspar and tungsten and also would have prevented federal aid to producers that declared dividends or transferred funds to surplus accounts during a year when aid was granted. Now that the bill is no more, the cry has been renewed for stiffer tariff action by the President who, after receiving Tariff Commission

recommendations for higher levies in April, said he would make a decision after Congress had considered the subsidy plan. If the Administration continues to balk at higher tariffs, as expected, the subsidy plan may again greet Congress in a revised form in the next session.

New Plants

Harvey Aluminum has started regular production at its aluminum reduction facility at The Dalles, Ore. Plant capacity, with two potlines comprising 240 units, amounts to more than 100 million lb of aluminum yearly. Hydroelectric power is generated, 5 miles distant, at The Dalles dam. . . . Beryllium Corp. has put into operation the first integrated privately owned U. S. plant for fabricating beryllium metal. Previously, an AEC plant was the only U. S. fabricator. While nuclear markets will claim bulk of output, the Hazleton, Pa., plant will also turn out aircraft experimental shapes. . . .Tantalum metal of extreme high purity has been developed by National Research Corp. and converted to high-density ingots weighing 100 lb and more. High grade powder was found amenable to arc melting. NRC's Cambridge, Mass., plant is now producing 30,000 lb a year and plans expansions.

African Bauxite Project

Olin Mathieson Chemical Corp. has joined four foreign firms in a $135 million project slated to develop French Guinea bauxite deposits and build an alumina plant with initial capacity of 480,000 tons a year. Olin Mathieson will have controlling interest in the new corporation, to be known as FRIA Compagnie Internationale pour la Production de l'Alumine. Construction will include a city of 4000 population, highway and railroad development, and improvement of the harbor at Conakry. Two French concerns will share in the project along with British and Swiss firms. Firms are: Pechiney Compagnie de Produits Chimiques et Electrometallurgiques; Societe d'Electrochemie, d'Electrometallurgie et des Acieries Electriques d'Ugine; British Aluminium Co. Ltd.; and Aluminum Industrie Aktiengesellschaft of Zurich. The alumina plant, to be operated by Pechiney, would be third largest in the world. If its expandable design were fully utilized, the plant would be world's largest, with capacity of 1.2 millon tons a year.

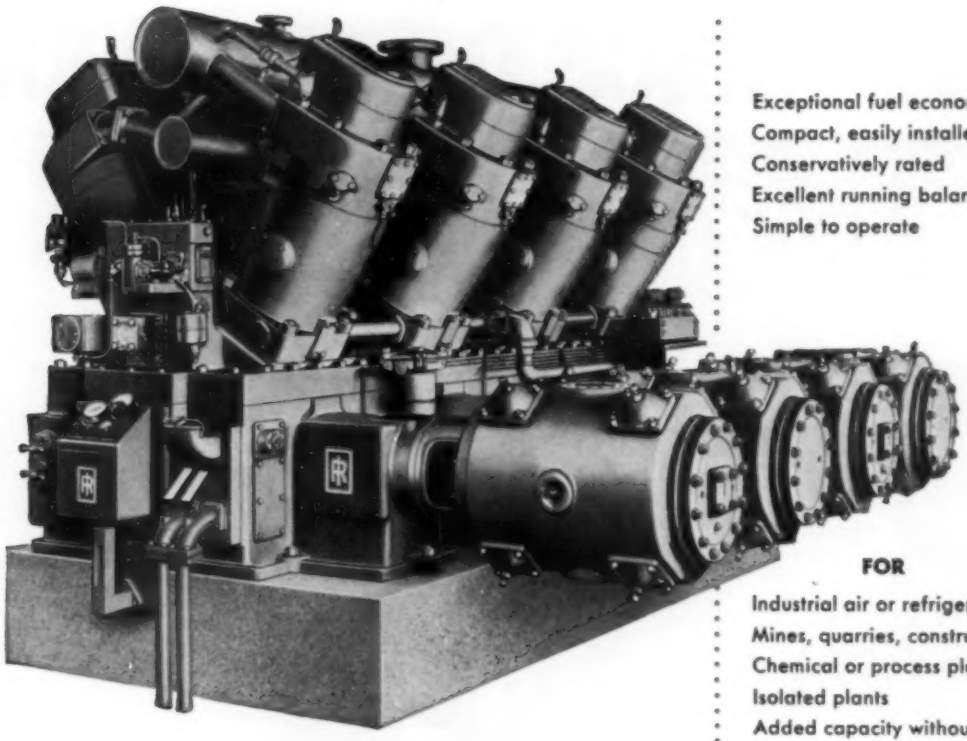
DMEA Passage Hailed by Applicants

The Defense Minerals Exploration Administration has recently received legislative approval to continue its financing of new strategic mineral explorations and the news has been welcomed by some 150 applicants for contracts with the agency. A bill restoring the DMEA program, which expired June 30, also includes an amendment calling for periodic progress reports to Congress.

USSR Sidesteps Tin Council Membership

Russia has refused an invitation to become a full member of the International Tin Council—and thereby be subject to its quotas and export restrictions—and instead has indicated that it might join as an *observer* member. Members bristle at the idea, commenting that market disturbances by the Russians would be increased if they had access to Council data without being subject to its regulations.

Ingersoll-Rand announces the SVO diesel-engine compressor



Exceptional fuel economy
Compact, easily installed
Conservatively rated
Excellent running balance
Simple to operate

FOR

Industrial air or refrigeration
Mines, quarries, construction
Chemical or process plants
Isolated plants
Added capacity without power demand

Integrally-built diesel-engine compressor provides unmatched operating economies!

The SVO is not an engine coupled to a compressor through power-wasting, space-consuming gears, but is an integral unit which combines a sturdy, low-speed, 4-cycle V-angle diesel engine with an efficient double-acting compressor on a single rugged frame with common crankshaft. It is the successor to Ingersoll-Rand's highly-successful XVO, which gained an unequalled reputation for dependability and economy in many years of service on numerous jobs.

The SVO is designed for continuous full-load compressor service at low cost. It is built in five sizes with 4, 6, 8, 10 or 12 power cylinders, for capacities from 1065 to 3200 cfm (at 100 psi). It can be furnished with compressor cylinders to handle air or gas at various pressures or vacuums. This machine will provide additional compressor capacity where electrical or steam generation facilities are already loaded or nonexistent, and is ideal for independent or isolated plants.

For full details, contact your local Ingersoll-Rand representative or write direct.

Only I-R compressors have CHANNEL VALVES

Known for high efficiency, quiet operation and exceptional durability. Entirely different. Each valve is a combination of rigid stainless-steel channels and leaf springs, with trapped-air spaces which cushion action, prevent impact.

Ingersoll-Rand 4-CYCLE

6-597

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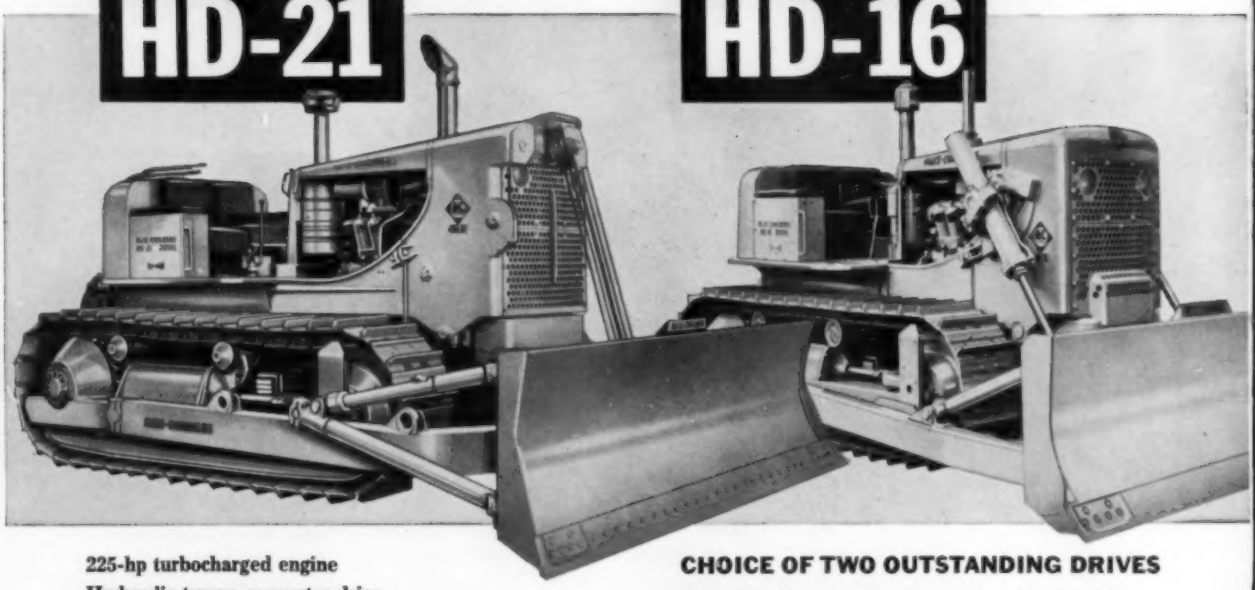
COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

ALLIS-CHALMERS CRAWLER TRACTORS . . .

first choice on more and

ALLIS-CHALMERS **HD-21**

ALLIS-CHALMERS **HD-16**



225-hp turbocharged engine
Hydraulic torque converter drive
56,260 lb (approx. as shown)

The new HD-21 brings you live power for today's big-tractor jobs—and torque converter drive puts it to work automatically. The HD-21 offers more work capacity—dollar for dollar—than any other big crawler tractor you can buy.
HD-21A illustrated—Two other models available

CHOICE OF TWO OUTSTANDING DRIVES

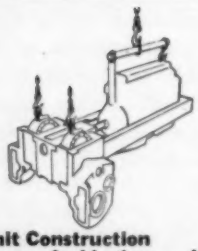
Hydraulic torque converter	All-gear drive
150 net engine hp	141 belt hp
39,090 lb (approx. as shown)	125 drawbar hp

Get up on the HD-16 yourself—and see how it handles jobs ordinarily assigned only to bigger, more expensive crawler tractors. You'll sell yourself—just as more keen-eyed construction men do every day.
HD-16DC illustrated—Five other models available

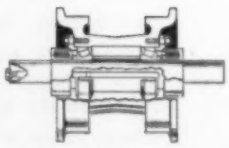
Pioneered and proved by Allis-Chalmers Engineering in Action

THE ONLY COMPLETE LINE OF CRAWLER TRACTORS

Torque Converter Drive gets more work done—automatically provides the right pull or push for every load, at maximum speed for existing conditions. *(Available in HD-21 and HD-16 only.)*



Unit Construction saves valuable time . . . lets you remove any major assembly without disturbing adjacent assemblies.



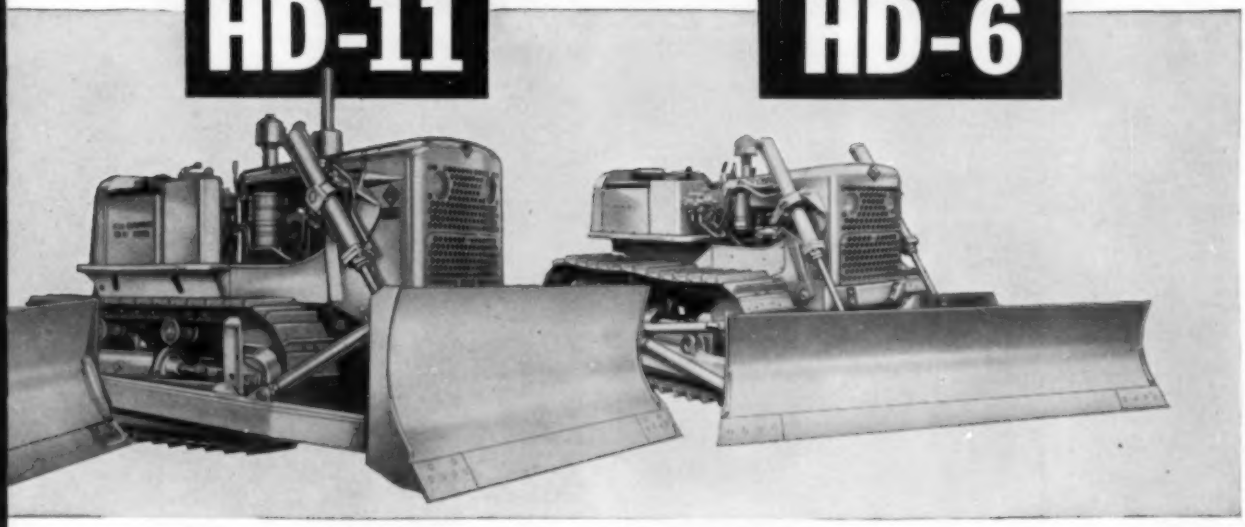
1,000-Hour Lubrication intervals for truck wheels, idlers, support rollers . . . changes daily greasing time into production time.

Look ahead...*move ahead*...and stay ahead

more tough jobs

ALLIS-CHALMERS HD-11

ALLIS-CHALMERS HD-6



94 belt hp

25,960 lb (approx. as shown)

The HD-11 is setting new standards in its size range . . . offers you dozens of work-boosting advantages, including the industry's easiest shift pattern. A single shift takes it from any forward speed to any reverse—gets short-cycle jobs done faster, easier.

HD-11B illustrated—Two other models available

63 belt hp

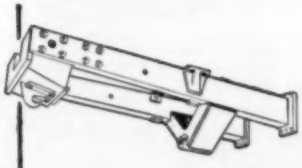
16,470 lb (approx. as shown)

Here's up to 15,500 lb drawbar pull. The HD-6 is the only tractor near its size with big-tractor design advantages—for example, All-Steel Box-A main frame and engine-mounted dozer with direct-lift cylinders for improved weight distribution, accurate dozing and long life.

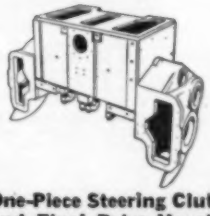
HD-6E illustrated—Three other models available

THAT GIVES YOU ALL THESE ADVANTAGES IN EVERY SIZE

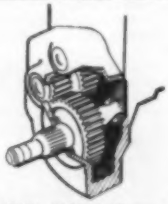
True-Dimension Track heat-treated and machined in the industry's most modern facilities, is setting new track-life records on every type of work.



All-Steel Box-A Main Frame soaks up shock and strain . . . provides improved weight distribution and equipment mounting.



One-Piece Steering Clutch and Final Drive Housing with extreme rigidity and strength . . . line-bored to provide precise alignment of gears and shafts.



Straddle Mounting of All Final Drive Gears with tapered roller bearings on both sides of short, large-diameter shafts . . . provides extra gear life.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

with ALLIS-CHALMERS

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SME Annual Meeting papers (February 17 to 20 in New York) have been preprinted and are still available; see list below. These preprints are available on a coupon basis. The coupon books may be obtained from SME headquarters for $5.00 a book (10 coupons) for members or $10.00 a book for nonmembers. Each coupon entitles the purchaser to one preprint. Mail completed coupons to *Preprints*, Society of Mining Engineers, 29 W. 39th Street, New York 18, N.Y.

5817A1—The Pima Open Pit and Haulage Facilities by Robert Thurmond.
5817A2—Mining of Magnetite and Martite at Benson Mine by Arthur F. Peterson, Jr., and Wm. P. Bach.
5817A3—Estimating Data for Haulage Trucks —Open Pit Mines by Howard Wilmeth.
5817A4—Problems in Mechanization in Primitive Countries by James V. Thompson.
5817A6—Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type by E. L. Ohle.
5817A9—Time Aspects of Geothermometry by R. J. P. Lyon.
5817A10—Ball Mill Performance at Super Critical Speeds by R. T. Hukki.
5817A11—A Study of Different Types of Steel for Grinding Media at Climax by F. Windolph and E. J. Duggan.
5817A12—Single-Stage vs Two-Stage Grinding at Homestake by C. E. Schmidt and F. M. Howell, Jr.
5817A13—Pebble Milling at Faraday Uranium Mines by R. J. Roach.
5817A13a—A Study of Grinding Ball Wear Employing Radioactive Tracers by A. L. Wesner, M. Pobereskin, and J. E. Campbell.
5817A18—Coal Mine Bumps Can be Eliminated by H. E. Mauck.
5817A20—Some Notes on the Principles of Mine Hydrology by H. E. LeGrand.
5817A23—Grouting and Water Control in the Kentucky-Illinois Fluorspar Area by Fred C. Wrobbel.
5817P1—Preplanning Safety in the Uranium Mining Industry by John E. Bailey.
5817P2—Increased Safety, Better Production, Through Use of Communication and Electronic Equipment by Earl A. Berry.
5817P3—Symposium on Safety and Health by James Westfield, John A. Johnson, Henry N. Doyle, and Miles P. Romney.
5817P9—Relation of Magnetic Susceptibility to Composition in Sphalerite and Minerals of the Wolframite Group by E. M. Spokes and D. R. Mitchell.
5817P10—The Metallurgical Story at Inspiration by C. B. Kettering and K. L. Power.
5817P12—Collector Mixtures and Collector Frother Emulsions in Sulfide Flotation by Arvid E. Anderson.
5817P13—Coal Preparation at the Humphrey Mine by Victor Phillips.
5817P14—Application of Mineral Dressing Fundamentals to the Solution of the Fine Coal Problem by M. C. Chang and John Dasher.
5817P16—New Concepts for the Dependable Lifting of Bulk Solids by Bucket Elevator by C. R. Davis.
5817P17—Removal of Heat in Cement Grinding by J. R. Tonry.
5817P18—A Critical Study of Thickening by A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell.
5817P19—The Application of a Jig for the Beneficiation of Sand and Gravel by John Meckenstock.
5817P20—The Application of Horizontal-Type Filters to the Metallurgical Industries by W. F. White.
5817P24—Economics Evaluation of an Industrial Mineral Project by J. E. Castle.
5817P25—Current Development in Gravel Beneficiation by W. L. Price.
5817P26—The Use of DSM Screens in a Heavy Media Cyclone Plant by W. R. Van Slyke, James Stukel, and L. D. Keller.
5817P27—Pima Mining Company Concentrator by G. A. Komadina and R. W. Herlund.
5818A1a—The Use of Ammonium Nitrate for Blasting at Mesabi Range Mines by Charles H. Grant.
5818A1b—The Use and Economy of Ammonium Nitrate Fertilizer Grade in the Open Pit Operations of the Anaconda Company in the Western United States and Mexico by A. C. Bigley.
5818A1c—Blasting with Ammonium Nitrate by Lewis J. Patterson.
5818A1d—Blasting with Prilled Ammonium Nitrate Fertilizer by W. M. Chapman.
5818A2a—Conveyor Belts at Miami Copper Co. by Benjamin R. Coil and James B. Fletcher.
5818A2b—Underground Conveyor Experience at Inland's Iron Mines by Howard M. Graff and James R. Gronseth.
5818A3—Raising by Use of a Cage by John C. Wangaard.
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5818A15—Solubility of Some Metal Ethyl Xanthates by P. S. M. van Heteren and P. L. DeBruyn.
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5818A17—Correlation of Contact Angle, Adsorption Density, Zeta Potential, and Flotation Rate by D. W. Fuerstenau and A. M. Gaudin.
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5819A14—Meeting the Challenge of Mining in Thirty Degree Pitching Coal Seams by Albert M. Keenan and Andrew Allan.
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5819P10—Boron—Its Past, Present, and Future by D. S. Dinsmoor and Frank Weishauph.
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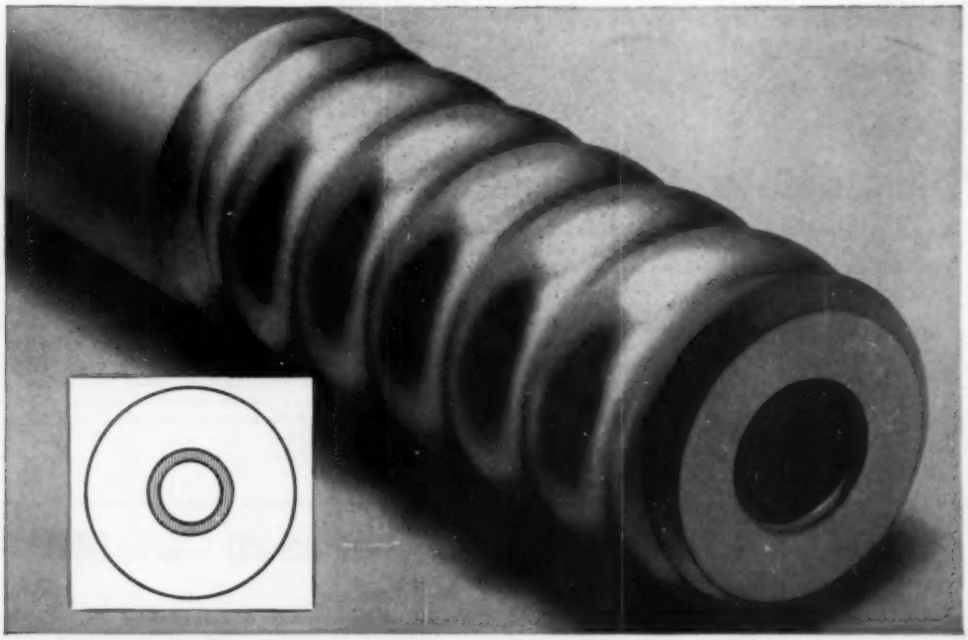
NEW ROPE THREAD MAKES UNCOUPLING EASY WITH SANDVIK COROMANT EXTENSION STEELS



Rope-Type Threads Afford No Starting Points for Fractures

Connections used in extension drill-steel must be easy to assemble and uncouple, and connections must not become weak links during the actual drilling. Sandvik Coromant's new patented rope thread makes it easy to join and uncouple the equipment . . . yet gives a solid and positive connection. The gently rounded form of this thread means trouble-free performance—eliminates common thread and coupling failures found in "saw-tooth" threads.

The complete equipment—bit, rod, coupling sleeve and shank adapter—are all dependable Sandvik Coromant parts made of world-renowned Sandvik alloy steel. A further advantage to the user is that the steel can be re-threaded. Atlas Copco has special literature on Sandvik Coromant extension steel and long-hole drilling, available to you with no obligation. We suggest you write today!

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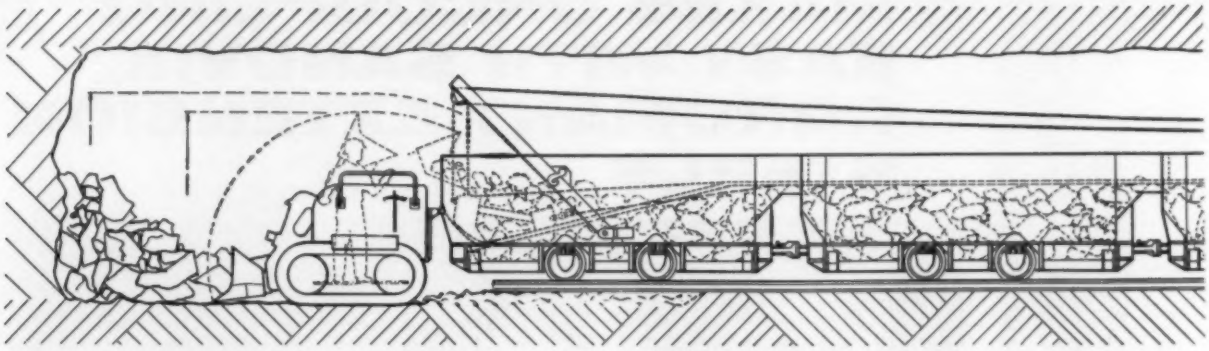
Distributors of COMPRESSORS, ROCK DRILLS, PNEUMATIC EQUIPMENT, SANDVIK COROMANT DRILL STEEL and CARBIDE BITS

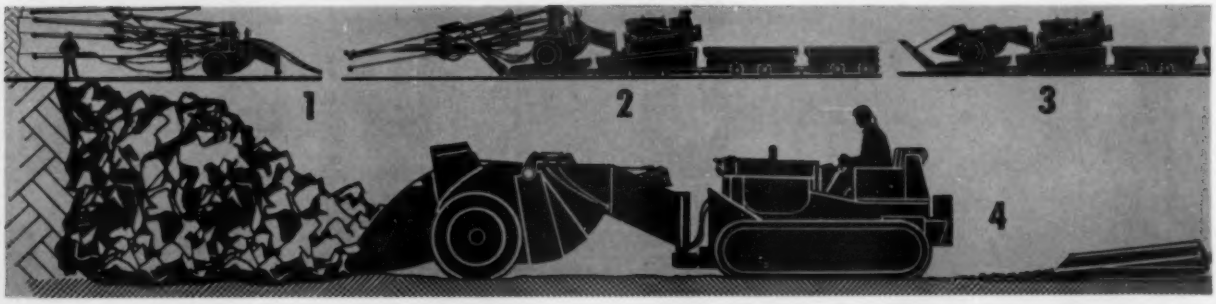
NEW S-D SLUSHER-TRAIN Promises You



"High-Ball-it" Speed and Safety Will Save You Days . . . Weeks

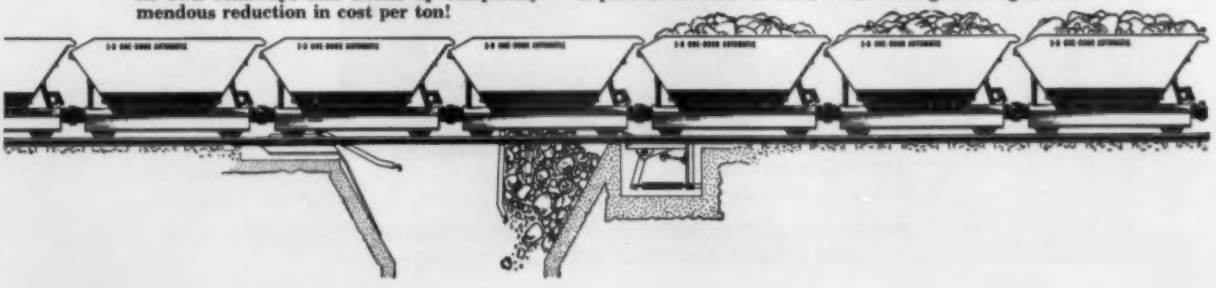
Here is what you have: (1) Equipment — Loader, S-D Slusher-Train and locomotive. (2) Men — only two . . . the loader operator and the S-D Slusher-Train operator, who becomes motorman when S-D Slusher-Train is in transit. Train is made up of S-D Automatic Bottom Dumping cars of any required number to give you the capacity to hold an entire round. Cars are not dumped until round is mucked-out and ready for next operation, drilling or timbering. There is no car switching, and no extra men required. Cars feature S-D, exclusive overlapping ends. You can figure on mucking out 1 to 1½ tons a minute. S-D Slusher-Train moves into face and remains stationary until entire round is mucked-out. Train is dumped by means of simple S-D Automatic tripping and closing devices. You obtain high speed mucking with less equipment, requiring less maintenance and fewer men. You get the muck out faster so you can start drilling again — saving days, sometimes weeks with fewer men in driving tunnels . . . obtaining tremendous savings in man-hours, maintenance and time! AND, same cars used in development can be used for production haulage!

S-D SLUSHER-TRAIN AND S-D GISMO® FEATURED

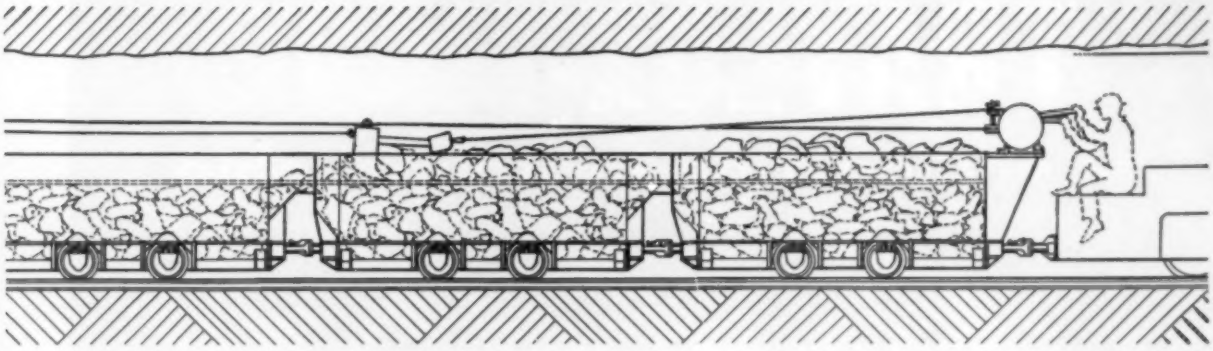


NEW ALL-PNEUMATIC-TIRED GISMO TRANSLOADER EXHIBITED

If you are attending the Mining Show at San Francisco Sept. 22-25, our Booth 840 offers you an excellent opportunity to investigate to your satisfaction the large savings available to you by operating with S-D SLUSHER-TRAINS . . . S-D GISMO . . . and new S-D GISMO TRANSLOADER. The Gismo equipment offers you a self-loading transport that loads (mucks) in development or production . . . transports . . . supports 2 to 5 jib-mounted drills . . . back fills . . . moves boulder rocks . . . makes its own roadways and cleans up completely — a proved method of hard rock mining offering a tremendous reduction in cost per ton!



Tremendous Savings in Tunnel Driving



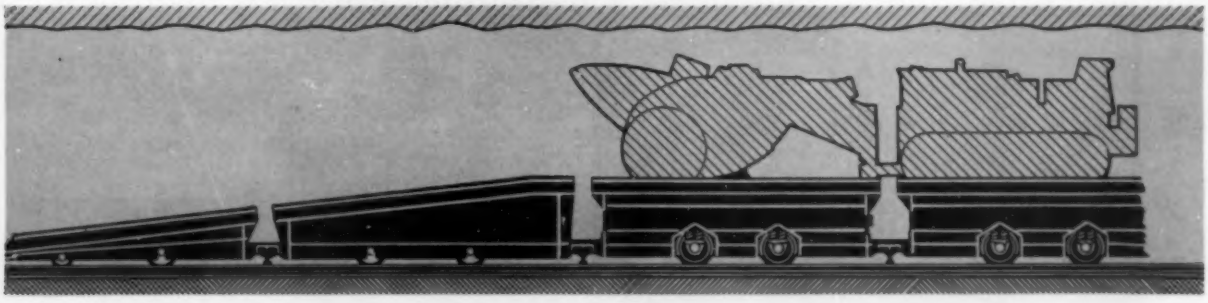
of time and Costs in Completing Jobs, based on today's Methods

The Gismo Ramp Car method is your answer to low-cost tunnel driving where larger cross sections are being driven, especially where a haulage drift is being driven in ore zone. In this way train can be loaded by the Gismo Self-Loading Transport without installation of ramp, chutes, etc. Regardless of which equipment best meets your requirements, S-D Slusher-Train, S-D Gismo or new S-D Gismo transloader the cars also become the most economical method for production haulage.

Illustrations show:

1. The Gismo Drilling Jumbo moves in to drill out a round with 4 drills operated by a two-man crew.
2. Drilling completed, Gismo Jumbo pulls out from face to ramp cars for transfer to another heading or side-track.
3. In the meantime, rock has been blasted at the previously drilled face and Gismo Self-Loading Transport is brought in for mucking and transporting operation.
4. While Gismo is mucking at the previously blasted round, loading cars one-after-another, the Drilling Jumbo can be set up at another heading in multiple heading development.

AT SAN FRANCISCO MINING SHOW SEPT. 22-25



S-D OVERLAPPING END ONE-DOOR AUTOMATIC

Gives you greater capacity for same overall dimensions . . . better trackability . . . low center of gravity . . . wide door opening . . . clean shedding . . . simple and low cost dump facility . . . ruggedness of design.

PREVENTS SPILLAGE

For complete information on S-D Slusher-Trains, S-D Gismo Equipment and S-D Mine Cars write us today.

Sanford-Day Iron Works, Inc.
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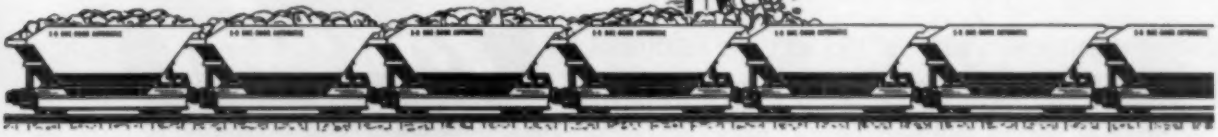

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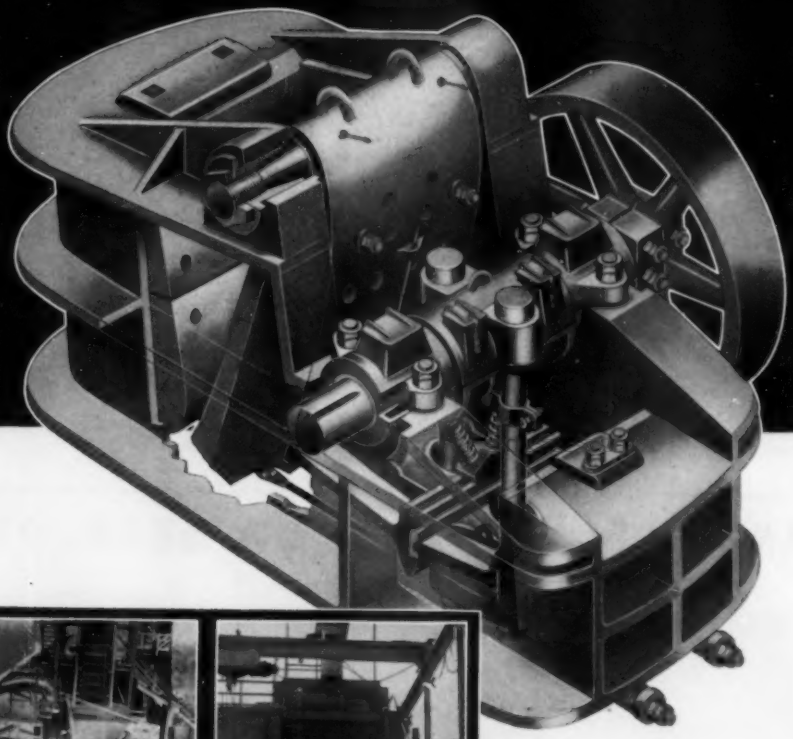
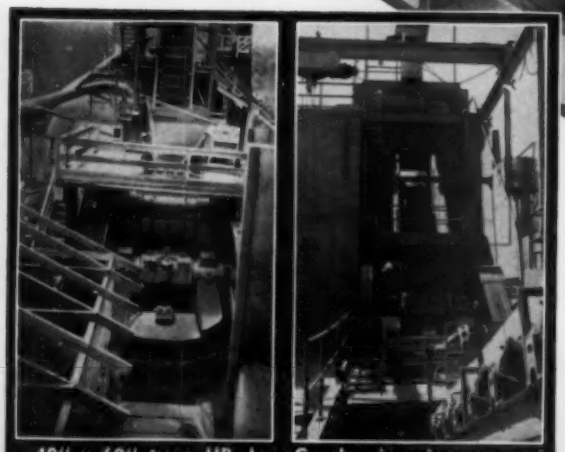
TRAYLOR-MADE

is engineering craftsmanship



Type HB
Jaw Crusher



48" x 60" type HB Jaw Crusher in primary service, reducing quarry material to desired size.

Cutaway view of the type HB Jaw Crusher shows the advance design characteristics of Traylor-Made Jaw Crushers—notice the sturdy bulldog pitman. One of the many important features of this crusher is the Traylor curved jaw plate. This design employs the principal of the famous curved fittings which have proved so successful and satisfactory in Traylor crushing machinery. Write for Bulletin #5105 for information.

TRAYLOR ENGINEERING & MFG. CO. 1083 MILL ST., ALLENTOWN, PA.

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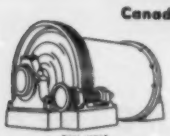


BALL MILLS

ROTARY KILNS

APRON FEEDERS

PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

MINING engineering TRENDS

Who's Vexed?

In 1957 the Minnesota Legislative Commission on Taxation of Iron Ore reported: "The history of taxation in Minnesota shows very clearly that iron ore has been taxed on a more onerous basis than any other class of property." Going on to explain the historical premise, diminishing assets, on which this taxation was based the Commission also pointed out that through the diminishing of these very assets that ". . . competition . . . is now a reality."

The situation has come to a head in recent months with announcements of increasing foreign iron ore investments and commitments at a time when the Mesabi is running well below capacity. At least some state legislators have begun to realize that tremendous capital investment and the future of one of Minnesota's major industries is at stake. Minnesota's Governor Freeman and Senator Humphreys have also gotten into the act—especially with attention U. S. Steel.

Long under cover, the differences in viewpoint of the state and the companies on the iron ore tax pattern are beginning to get an airing in the press. *Business Week* headlined its story, "Iron Imports Vex Mining States" and could well have backed it up with a second head, "Iron Ore Taxes Vex Mining Companies."

More on Iron Ore

The item last month in "Trends" on projected 1975 iron ore demand and possible Canadian production to meet that demand contained an error: the figure for Steep Rock should have been 10 million tons. A compilation by Thomas C. Denton and Justin B. Gowen of the USBM sheds further light on another of the figures in that item, the estimate of 15 million tons export to Europe.

The figures given by Denton and Gowen are from countries accounting for 92 pct of the pig iron produced in non-communist Europe. In comparison with actual 1956 consumption of 3.2 million tons from South America and 4.1 million tons from Canada they project that by 1965 Europe's imports from South America will have risen to 5.8 million tons and from Canada to 8.0 million tons.

Extension of these figures for another decade indicates that by 1975 at least 16 million tons of iron ore will be imported from Canada. That Europe's total iron ore imports will rise at a faster rate than overall steel production is assured if one compares the low grade of internal ores consumed in 1956 (35 pct Fe average), with the grade of imported ores (about 58 pct Fe). Additional ore must largely come from abroad, since marginal ores are already in heavy use at home. African iron ore projects will play an increasingly important role in sustaining the growing steel industry of Free Europe, but the flow from South America and Canada will also increase.

Metaline District Studied

The City of Seattle has announced that its geologic, hydrologic, and engineering study of the Metaline mining district in northeastern Washington has been completed. The study was made in conjunction with its application to the Federal Power Commission for license to construct and operate a hydroelectric project at the Boundary Site on the Pend Oreille River. Currently, there are two substantial mining operations in the district: that of Pend Oreille Mines & Metals Co. and that of American Zinc Lead & Smelting Co.

Some of the mining companies holding land in the district vigorously opposed the application, stating that the proposed normal pool operating elevation of 1990 ft would render certain ore unminable, and that some if not all of the area below the reservoir level would have to be abandoned. Because of the importance of the Metaline district as a source of lead and zinc, and because of the possible liability as an operator of a reservoir should damages occur, Seattle undertook a comprehensive study.

The cooperation between the City and interested mining companies has been excellent. The City's work, begun in 1957, has been under the direction of Wisser & Cox, consulting geologists of San Francisco, and Leggette, Brashears & Graham, groundwater hydrologists of New York City. More than 20 years of investigation by the U. S. Geological Survey, U. S. Bureau of Mines, and interested mining companies has resulted in a great volume of information being available. Review of available data plus independent field studies early indicated a general water tightness and high ground water pressure in the vicinity of the operating mines. This was interpreted by the City's consultants to indicate conditions were favorable for coexistence of a

(Continued on page 954)

hydroelectric project and underground mining, but certain data not obtainable by past investigations were required.

The City, in cooperation with the mining companies, then undertook recapture of certain mining company holes and the drilling of 16 new pumping and water observation holes also designed to yield necessary structural information. This drilling program, now completed, gives for the first time a clear picture of groundwater gradients and volumes in this mining district.

According to the consultants, the normal operating pool level of 1990 ft proposed by the City will raise water level in the vicinity of the operating mines from 3 to 60 ft, or stated another way, from 1 to 15 pct of existing static heads. "The newly gathered information, together with a record of 20 years mining operation, much of it below river level, clearly indicates to the City's consultants that these increases in static heads due to operation of a reservoir should not cause excessive increases in mine pumping and will not inundate any mine facilities."

The geologic, hydrologic and engineering problems in this study are obviously complex. It is anticipated that a public hearing before the FPC will be held in the near future, at which these data will be thoroughly discussed. To aid in visualization of this complex project, the City has commissioned a three-dimensional model of the entire project area constructed with engineering precision. The model, now nearing completion, is approximately 4x12 ft and shows not only surface but also underground features and their relation to the increased water heights in the Pend Oreille River resulting from creation of the proposed reservoir.

Two Films

Refining Nickel is the third film of Inco's motion picture series of its nickel operations. They have presented the story of how nickel is mined (*Mining for Nickel*)—how it is milled and smelted (*Milling and Smelting*)—and now present the story of its refining. All the best devices of modern motion picture technology have been used in the series to make complex process clear to the nontechnician, while not insulting those familiar with mining. All in all, the outstanding series of mining films. Further data on viewing these films was given in *ME* August under "New Films" facing page 845, or may be obtained by writing the distributors, Rothacker Inc., 729 Seventh Ave., New York 19, N. Y.

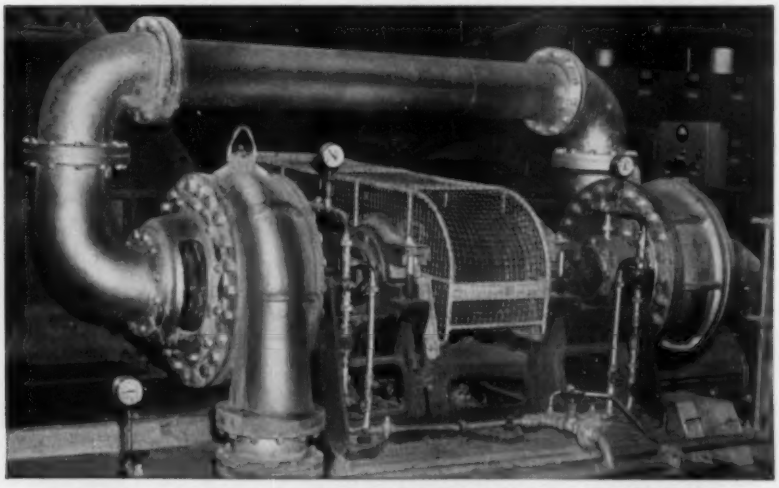
Producing America's Buried Treasure is a new 20-min, 16mm sound and color film released by the Georgia Marble Co., Tate, Ga., and showing the company, its operations, the products, and their uses. For further information please write the company.

Correction

Automation in the Mineral Industries. By John McCaslin. (MINING ENGINEERING, March 1958.) Captions for Figs. 2 and 3, pages 338 and 339, should be interchanged to read as follows: "Fig. 2—Relationship between resistance and temperature for an ML-419/AMT-4 thermistor." Fig. 3—Output of the Wheatstone bridge with variation resistance of leg C."

handling the slurry in a hurry

for the South African Electricity Supply Commission . . .



Operating as boosters, these 2-stage Linatex pumps have a capacity of 1,800 gallons of slurry per minute. The pumps were supplied to the South African Electricity Supply Commission to meet the demand for installations that could handle large quantities of boiler dust slurry without wearing out. With a first stage intake of 50 lbs. per square inch and a second stage discharge of 160 lbs. per square inch, the pumps have proved—once again—the operating efficiency and long-lasting qualities of the Linatex pump.

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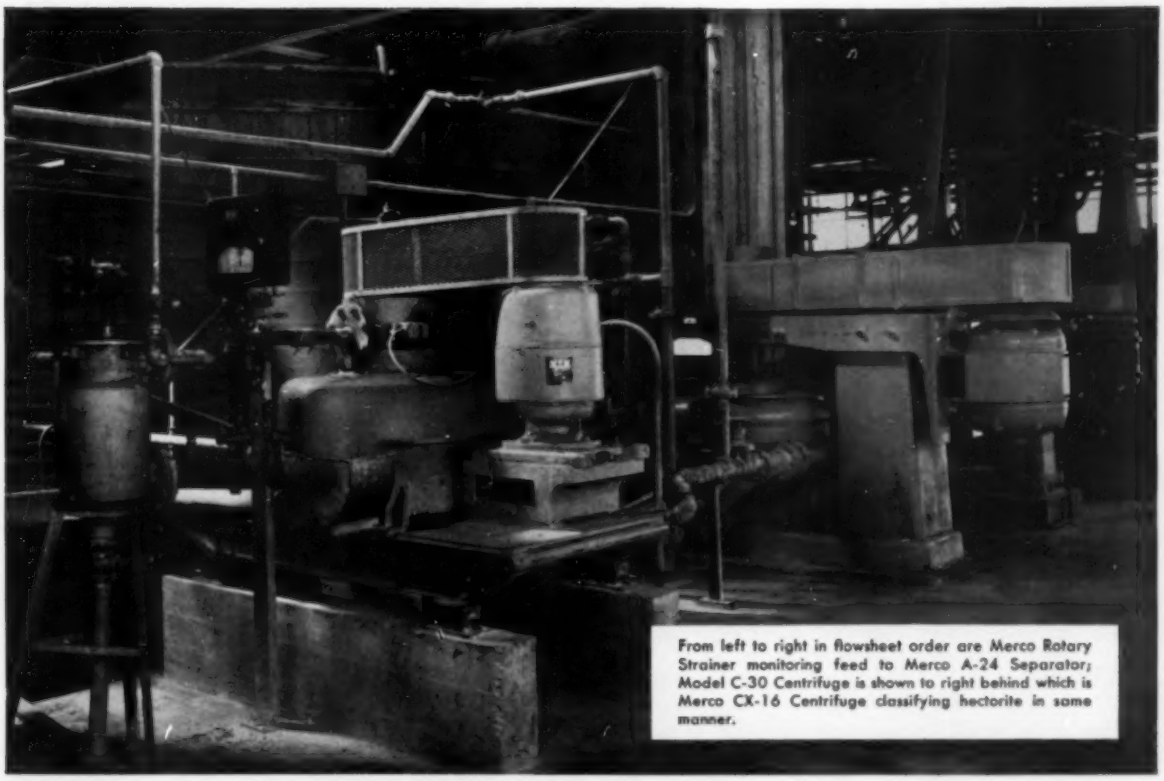

From left to right in flowsheet order are Merco Rotary Strainer monitoring feed to Merco A-24 Separator; Model C-30 Centrifuge is shown to right behind which is Merco CX-16 Centrifuge classifying hectorite in same manner.

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The AIME also publishes:
Journal of Metals—monthly
Journal of Petroleum Technology—monthly
Transactions of The Metallurgical Society—bimonthly

Getting Behind the Building Fund

The Industrial Gifts Campaign for the United Engineering Center is well on its way, with total subscriptions by August 15 in excess of $3¾ million, of which corporations in the New York area alone pledged $2.6 million. In the overall campaign, as in other phases of the new engineering center project, members can take pride in the leadership exerted on their behalf by prominent AIME members.

AIME's presidents for the past several years have played active roles in bringing the Center to reality, particular note going to H. DeWitt Smith, one of AIME's representatives on the 15-man steering group; and Andrew Fletcher, Vice President of United Engineering Trustees.

Undertaking a $10-million building program took courage, but it was not undertaken without the most searching analysis of needs, alternatives, and means. It was recognized early in the study that the matter of financing would have lasting effects on the societies and their members. Among the alternatives were these:

1) To disperse the societies and rent office space.
2) To build a new center taking available resources plus a mortgage for the balance.
3) To ask for industrial support of a new center worthy of the profession.

The first alternative meant space costs far higher than in the present building. Reduced services and higher dues must then be faced indefinitely and the unity of the profession would be weakened if not destroyed.

The second possibility would have kept the societies together in their own building, but would again have faced the society membership with higher dues or reduced services or both for years to come.

The third course was deemed the only one of courage *and wisdom*, taking the future into account. Low building space costs and unity of action had proved a bulwark to the Founder Societies through two world wars and a major depression.

Industry was approached through a group of interested leaders. They gave this reply: "We will help—but what are the engineers willing to do for themselves?" Again, there were alternatives in the means of raising the balance (more than two thirds would be available from reserves and an industrial gifts campaign). Dues could be increased for some years to come; or a membership fund drive for 30 pct of the cost. The second course was chosen.

Industry *has done* and is doing its share. On page 961 you will find a summary of the project—its aims—and *your* role in that project.

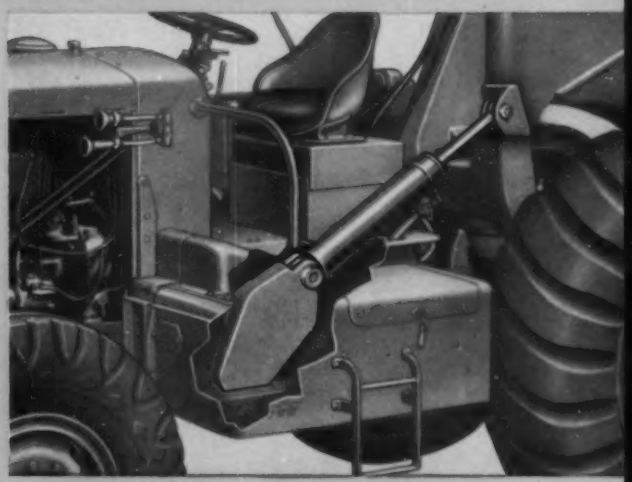
Thanks to personal efforts on AIME's behalf by a few prominent members, the miners once again led the way—this time in the first few weeks of the Member Gifts Campaign. But it is only a start. AIME members have a quota of $500,000 to raise. Vice President J. L. Gillson, with aid from Philip Wilson, Mike Haider, and O. B. J. Fraser, has organized the program. Joe Gillson will do his job, and from here out it will be up to us as members to do ours. I can do no better than quote Charles F. Kettering, Honorary Chairman of the Member Gifts Campaign for UET:

"The program is sound. It is timely. It merits your support."

"To you—my fellow engineers—I extend my personal endorsement of the project. I urge you to give, not only in dollars, but in service to the campaign."

This fall every Member and Associate Member living in the United States will be, or will have been, approached. When you receive the pledge card, you will have a rare chance to help build the engineering profession to its proper status in America and the world.—*R. A. Beals.*

REDUCE COSTS... INCREASE EFFICIENCY



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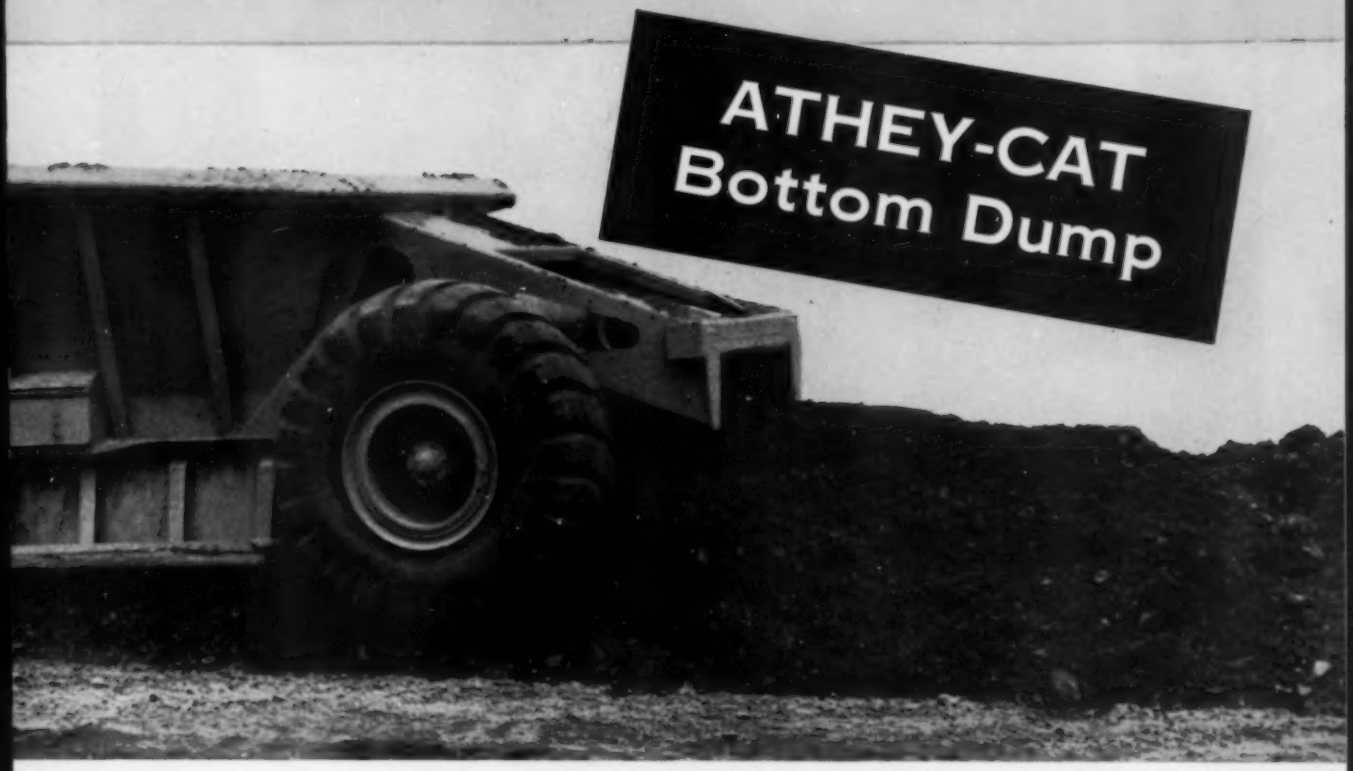

Caterpillar DW20-Athey PW20 Bottom Dump teams trim the non-productive costs out of stripping and increase efficiency. The big reason? Lower costs per yard compared to other hauling units. The advanced design and premium construction of this new hauling unit provide the key to big production, low-cost stripping. Check these advanced features of the DW20-PW20:

Big Capacity — No Dead Weight: Rated 40-ton payload is nearly 4 times the trailer weight! High-strength "T-1" steel permits use of thinner plates to greatly reduce weight with no loss of strength. Even with a 27 cu. yd. (struck) capacity, the PW20 has a low 8' 9½" side loading height to speed shovel loading.

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Faster Dumps: The big, wide (6') bottom doors of the PW20, its steep 18° side plates and its exclusive rear, or third door, permit it to dump fast and clean every time. And with a high arch (5') axle, the unit rides out over, not through, the dumped load. No more "hang ups" or wasted time on the dump.

Less Maintenance: Trouble-free design and hard "T-1" steel combine to make the PW20 a rugged performer that stays out of the shop and out on the job. "T-1" has a high impact and abrasion resistance not found in ordinary steels and because of its low temperature impact resistance, it retains excellent characteristics even in sub-zero temperature. Get the full story on the DW20-PW20 Bottom Dump team from your Athey-Cat Dealer. Ask him to show you the new 16-mm film on the unit.

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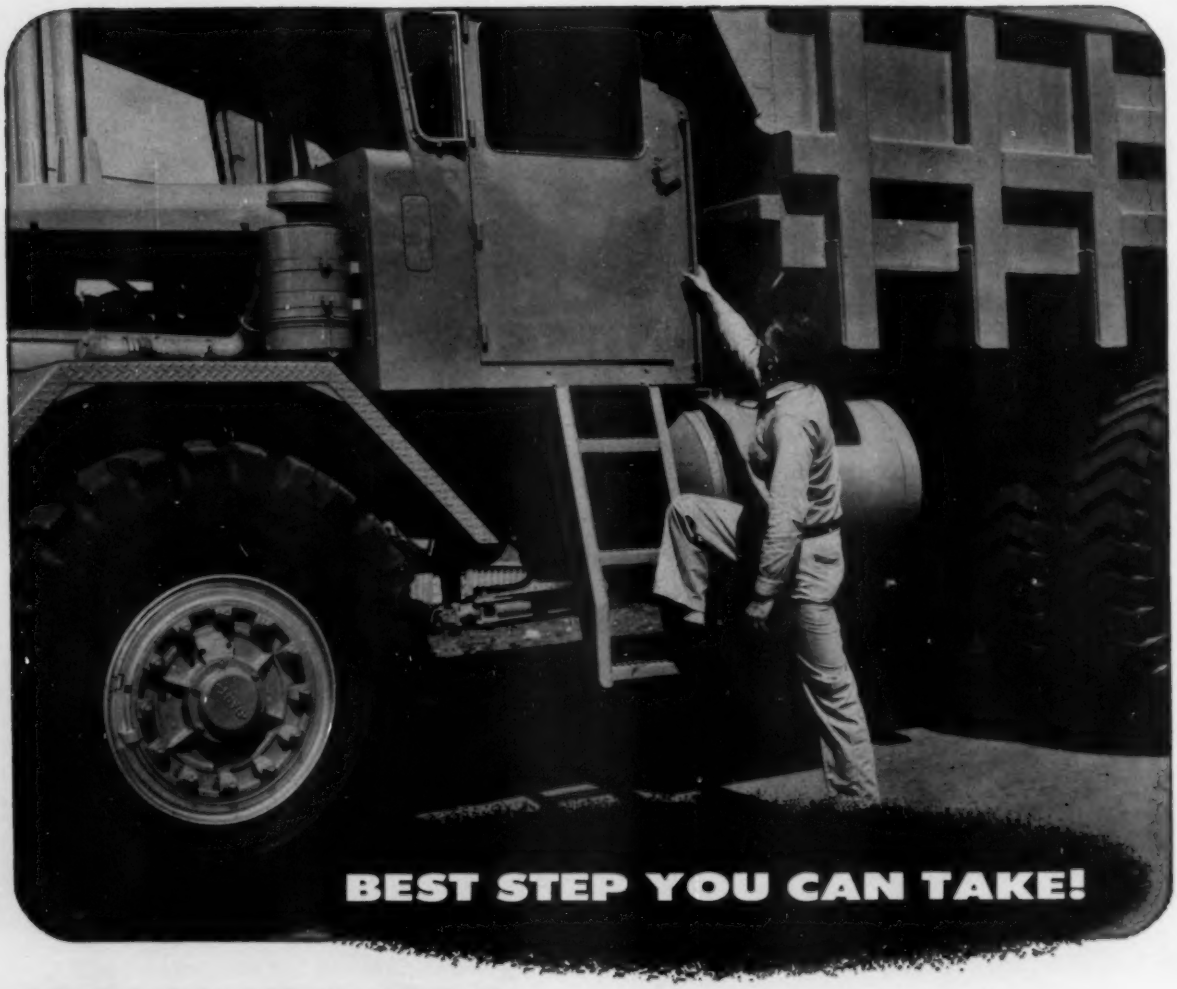

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YOUR INVESTMENT IN THE ADVANCEMENT OF AMERICA'S ENGINEERING LEADERSHIP

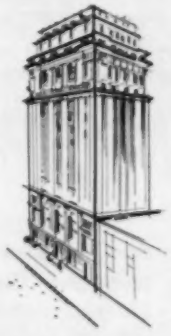
—the new United Engineering Center

"America cannot afford to be second best,"—the Honorable Herbert Hoover

IN maintaining leadership for this country no group will play a more important part than engineers—men qualified by training, experience, and ability to meet the demands of an era that will witness technological and scientific progress surpassing anything known heretofore.

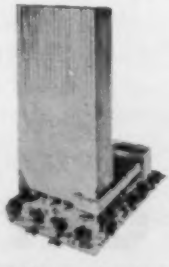
Within the past half century the profession has increased mightily in stature. In numbers alone the five Founder Societies have grown elevenfold since 1907. Student members and members of the Associated Societies in the project swell the total to more than a quarter of a million.

Through their overall organizations the Societies have achieved a highly cooperative relationship, once symbolized and made effective in the present Engineering Societies Building, given by Andrew Carnegie half a century ago as "a home for engineers." This relationship is now to be renewed and strengthened in the new United Engineering Center.



Constructed more than 50 years ago, the present headquarters of the Founder Societies at 29 W. 39th St. was both attractive and ample in size during those untroubled days when Theodore Roosevelt was President of the United States and membership of the societies was but 16,000. *Today*, the structure is outdated and completely inadequate to the needs of a membership that has jumped to 180,000 and is still growing.

The new center is to be THE CENTER of the engineering profession—The impressive 20-story tower will be entirely functional, standing as enduring evidence of the unity and strength of the engineering profession. The Center will contain 250,000 sq ft of floor space, to meet all present requirements of the Founder Societies and provide for the various associate societies that desire to have their headquarters in the new building. In addition the design provides for expansion with continuing growth of the profession.



Everything about the Center will be designed with a single purpose in mind—effective, efficient, and economical service to member engineers throughout the country and wherever they may be. It will improve service to members, provide distinct economies through joint operation, and advance the individual members' continuing quest for knowledge.

An Investment to Further Engineering Progress—This is not a small project. Total cost of the new United Engineering Center, including the site, is estimated at $10 million. Of this more than two thirds—$7 million—will be met by present resources of the United Engineering Trustees and through the $5 million Industrial Gifts Campaign. Industry has already subscribed more than two thirds of its share.

What Will the Engineers Do for Themselves?—To the individual member the Member Gifts Campaign is both a challenge and an opportunity.

It is a challenge to you as a member of a true profession to give generous support to the most significant project your profession has undertaken during your lifetime.

In contrast to other annual appeals for funds, the Member Gifts Campaign is an opportunity to make a once-in-a-lifetime gift. Moreover, your gift as a member will serve as an ever greater stimulation to the Industrial Gifts Campaign.

The overall program calls for utilization of three sources of funds to meet the $10 million goal of the building project: Present UET resources, $2 million; Business and Industry, $5 million; and $3 million from the Member Gifts Campaign. AIME's proportionate share of the membership campaign is $500,000. (This has been divided among the Founder and associate societies in proportion to membership.)

AIME appointed J. L. Gillson, Vice President and nominee for President-Elect in 1959 as overall chairman of its share of the fund drive. Three well known members assisting Vice President Gillson are Evan Just for SME, O. B. J. Fraser for TMS, and M. Haider for SPE.

The industrial campaign has already received massive support and is well on its way toward the final goal. AIME has led in this share of the fund raising program. Under Vice President Gillson the Member Gift Campaign is off to a good start. In the first phase some leading members are being canvassed personally—in coming weeks the entire membership will be canvassed.

From the very beginning the fund drive has had the wholehearted support of a veritable *Who's Who* of American industry, engineering, and education. No finer endorsement can be quoted than that of the nation's most honored engineer:

"We urgently need to start our new building. It is of national importance. We need the support of all our members." —the Honorable Herbert Hoover.

1,000 Cu. Yd. per Hour Performance with 4 Cat Scraper-Tractor Combinations

Bucking weather and terrain, Cat DW20 Tractors with No. 456 Scrapers removed overburden on this uranium mining operation in Wyoming. The contractor used four DW20s to strip an average of 1,000 cu. yd. per hour.

W. N. McMurry, secretary-treasurer and co-owner of Rissler-McMurry of Casper, Wyoming: "I like the stability of the DW20!"

Mining uranium near Riverton, Wyoming, Rissler-McMurry used four Cat DW20s with matching No. 456 Scrapers to strip overburden at the lowest possible cost per cu. yd. This contractor, working for Vitro Minerals Corp., has utilized Caterpillar machines for 16 years. The owners like the stability, economy and power of their fast wheel scraper-tractor combinations for loading and hauling. They also relied on the rugged punch of a Cat D9 Tractor, a maneuverable D8 and a No. 12 Motor Grader to get the job done on schedule.

The DW20s excavated a 350,000 yd. pit—moving an average of 1,000 cu. yd./hr. Average depth of the pit was 66 ft., and material consisted of loosely consolidated sandstone and gravel plus cemented claystone in the pit's bottom. The DW20s handled a 600-ft. 10% ramp at one end of the pit with ease.

Now the new DW20 (Series F) rig is faster than ever and packs even more punch. Powered with a brand-new Caterpillar Engine, HP is increased to 320 (maximum output). At equal rimpulls, speeds are 10% greater. And torque rise is more than doubled compared to previous models. So the big wheel units give faster cycling for high production and wider profit margins. Combined with a Caterpillar LOWBOWL Scraper, the DW20 is the top earth-moving team for pit mining and other tough jobs.

For an on-the-job demonstration, get in touch with your nearby Caterpillar Dealer today. Find out for yourself if wheel tractors and scrapers can do your stripping more profitably than trucks and shovels.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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HAUL AT LOWEST COST PER CU. YD.

Prominent ridges mark terrain in area of Lovitt gold mine.

GEOLOGY OF THE LOVITT GOLD MINE, WENATCHEE, WASH.

by E. H. LOVITT and A. C. SKERL

After nine years of continuous operation it is a good idea to take stock of the geological concepts that guide the working of a mine. This is a welcome opportunity to discuss the Lovitt gold mine, which has been a challenge in both the geological and operational fields.

The occurrence belongs to the extensive group of epithermal gold-silver deposits once worked so vigorously in the western states, Hungary, and New Zealand and still producing in Central America and the Philippines. These deposits are characterized by a relatively shallow vertical range up to 2000 ft, and often much less, and by bonanza orebodies of even more limited range. The area in which they occur is frequently widespread, so that exploration must be directed along and across the strike of known favorable structures in search of repetitions.

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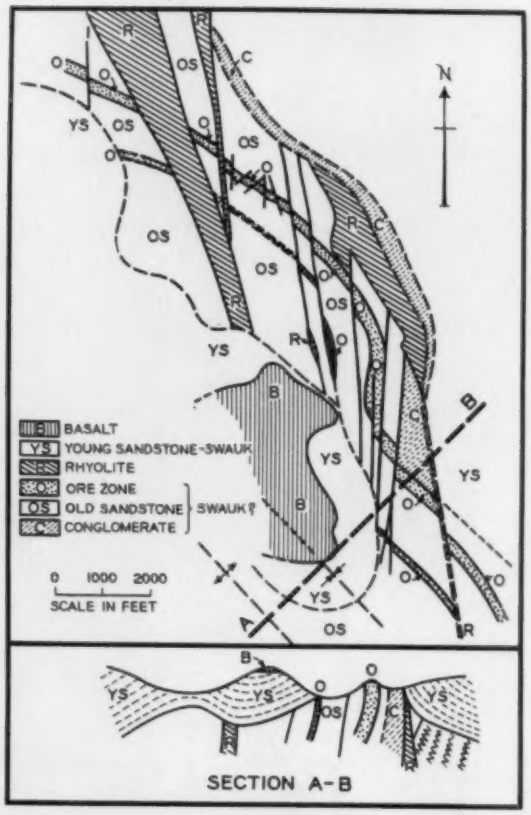
AIME Pacific Northwest Regional Conf., April 1958, Spokane, Wash.

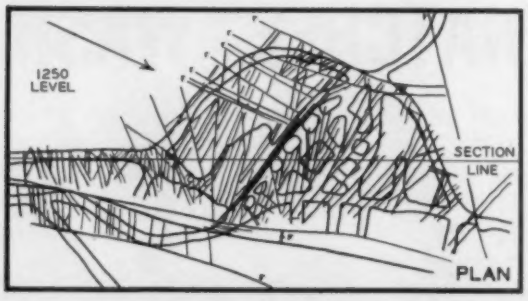
Location: The Lovitt mine is ideally situated near the paved highway that extends up the Squilchuck Valley about three miles from Wenatchee, Wash., and a mile and a half from the Columbia River. Rail transportation, too, is excellent, supplies are plentiful, and repair services close at hand. Electric power is obtained from Chelan County Public Utilities Div., which has an excellent source of energy in the Columbia River. The operation is also fortunate in having experienced miners.

History: The ground was first staked in 1885 as the Gold King mine, and in 1894 a small five-stamp mill was erected. Since recovery was very poor, milling soon stopped and has never been resumed. It is now known that the reason for low recovery was the finely divided state of the gold, which the comparatively coarse grinding by stamps did not liberate for amalgamation to be effective. Cyanidation had only recently been introduced and was probably not appreciated by the operators.

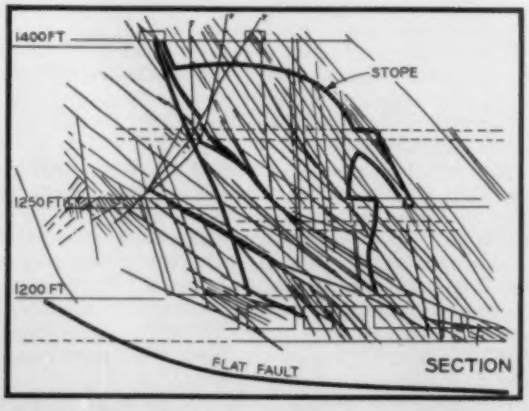
The two key claims were always kept in good standing, and J. Keegan of Wenatchee, obtaining



Distribution of rock types at Lovitt mine.



49 ORE BODY



Detailed cross section of orebody at north end of mine.

an option in 1934, explored the holdings and interested various mining companies in his findings. Considerable tunneling and sampling were carried out, but it was not until 1949 that the operation became a success, under Lovitt Mining Co.'s management.

From initial production in August 1949 to the end of 1957, 446,025 tons have been shipped to the Tacoma smelter, where the highly siliceous ore is found to be an excellent flux. Gross content of this ore—189,404 oz of gold and 217,328 oz of silver—has been valued at $6,612,569 and averages $14.80 per ton.

GEOLOGY

The Wenatchee area is mostly underlain by gently folded continental deposits of Eocene age known as the Swauk Formation, which consists of sandstones, shales, and conglomerates that are often only partially consolidated. Above an elevation of 2000 ft there are flat-lying Miocene volcanics, known as the Columbia River lavas, which must once have covered the entire area.

Sediments of the mine formation, the oldest rocks exposed in the area, resemble the usual Swauk sediments except that they are fractured and better indurated. They were tilted up on edge to form an island chain against which the Swauk sandstones were piled. This relationship suggests the oldest sediments could be cretaceous age.

The accompanying map and section show the distribution of rock types. The belt of mine rocks stands at a steep angle with about 1000 ft of older coarse conglomerate to the east and a sandstone-shale series overlying it in the form of synclines on both sides. In the past, lignite seams have been explored in these younger sediments. They also contain a layer of silica sand that was once exploited.

The area was sliced up by a northerly trending zone of steep faults, probably before the younger sediments were deposited. These faults are believed to be the southern extension of the Entiat fault.

Subsequently both rhyolite with perlitic facies and minor andesite were intruded as dikes along some of these faults. The sediments in the mine belt became pyritized, silicified, and permeated by numerous quartz veins over a distance of two miles and a width of 300 ft.

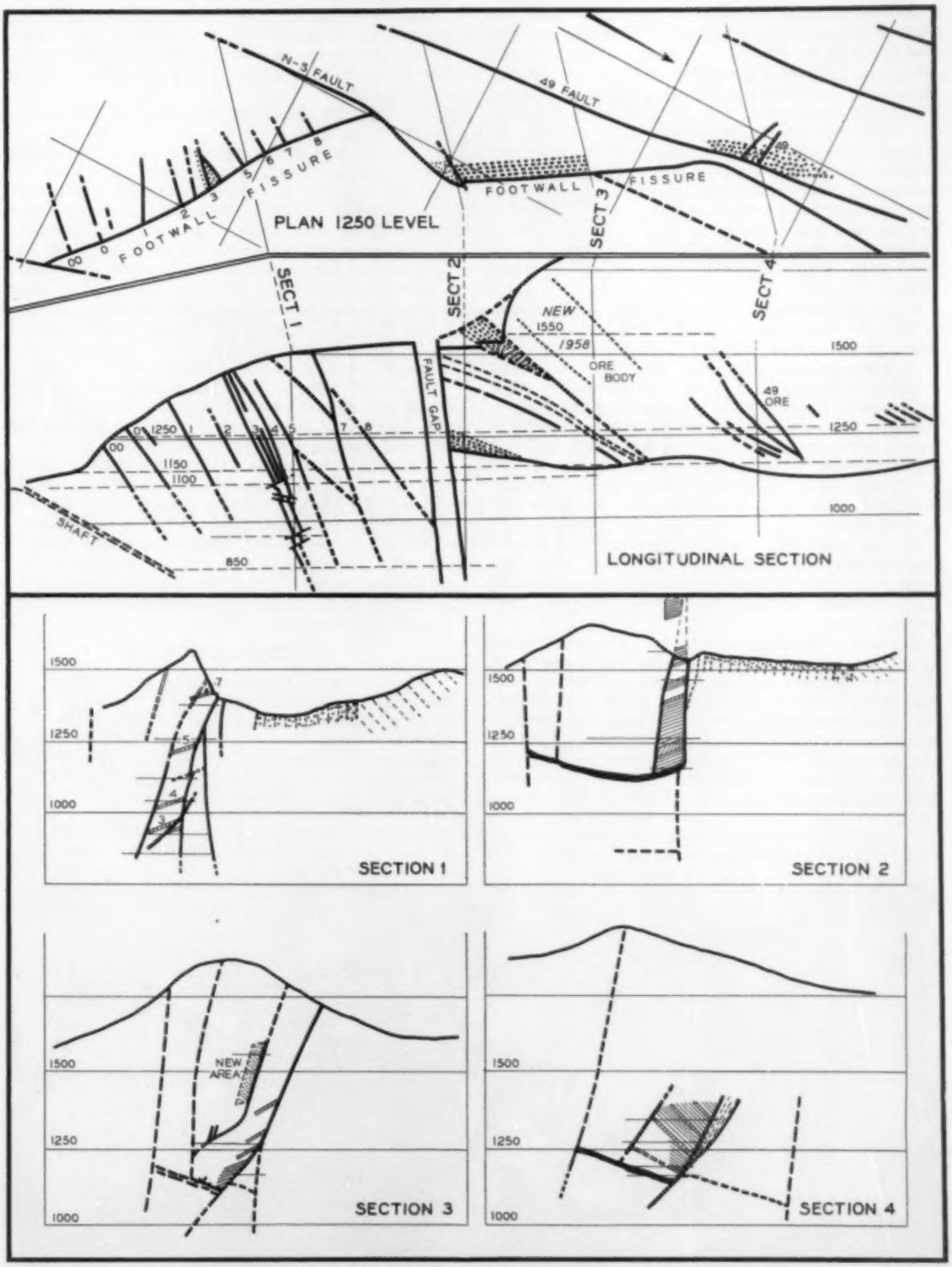
Mine Geology: A typical section from east to west through the mine shows several hundred feet of conglomerates with mostly vertical dips. There are then about 100 ft of feldspathic sandstones with minor clay seams. Next there is the important footwall fissure, a clay bed with associated argillaceous sandstone up to 50 ft wide and dipping steeply west. This is followed by more feldspathic sandstone with some pebbly layers for a few hundred feet—the sandstone is usually pyritized and often highly silicified. Clay partings and thin argillaceous beds often show signs of movement.

Completely carbonized plant material such as leaves, twigs, and small logs are common in the sandstones, especially near the footwall fissure.

Cross-bedding, both large and small-scale, is typical in these sandstones, which are of lacustrine origin.

The only intrusive found in the mine workings is some perlitic rhyolite in the conglomerate horizon near the portal of the main haulage tunnel on the 1150 level.

At times a fine-textured dark arkose with scat-



Above: Simplified plan of faults and veins on 1250 level, with corresponding longitudinal section. Section 1: Cross section of veins in southwest area. Section 2: Location of orebody in angle between footwall fissure and flat-lying fault. Section 3: New area recently located along secondary faulted clay bed. Section 4: Generalized cross section of principal orebody at present north end of the mine known as the "Forty-Nine." See opposite page for detailed section.

tered feldspar grains simulates a bedded dike rock.

Structure: The major fault zone in which the mine is situated consists of more than ten parallel tear faults in a width of 1½ miles, as shown on the geological map of the surface. The movement was apparently such that the east side of the area moved a half mile south relative to the west side. The weak clay beds and seams took up some of the movement.

Between two of the main faults a block some 1000 ft wide has moved south on a flat-lying fault. The amount of movement is not yet known and ore has only recently been found below this fault. Where it has cut obliquely across the weak clay with interbedded sandstones it has produced a zone of lustrous shale fragments with blocks of broken sandstone.

As mentioned above, a shale horizon near the base of the older sandstones became a strong fault known as the *footwall fissure*. The sandstone beds adjacent to it were severely dislocated in several directions to produce fractures that were subsequently filled with quartz to form veins and systems of veinlets.

Veins: The mine is divided into two areas by a strong north-trending fault. In the southwest area the auriferous veins always dip 60° to 80° to the north and in the northeast area 30° to 50°. The northeast area is underlain by the flat fault described above.

In the southwest area there are later south-dipping and vertical barren veins that offset the auriferous veins. In the northeast area a series of north-trending vertical veins also offsets the ore-bearing veins.

There is a fairly regular pattern of major veins, especially in the southwest area, that have been mined as separate entities, but the bulk of the tonnage produced is from zones of veins and veinlets that extend as much as 300 ft along the footwall fissure on the level, for a vertical range of 200 ft, and an average of 50 ft out from the fissure. Much of this ore is mined *en masse* by rings of long holes. Where the average grade is too low it is sometimes possible to stope out a high grade vein selectively.

Significant gold values have been found on the surface up to an elevation of 1800 ft and underground down to the lowest exploration drillhole at 750 ft—a vertical range of a least 1050 ft for occurrence of ore.

So far stoping has been done from an elevation of 850 ft up to 1600 ft.

Mineralogy: The vein quartz is cherty and usually pure white, with vague patches and banding that are slightly grey in color. Sometimes a vein consists partly or wholly of black chert, often a sign of good ore. In some areas large masses of sandstone have been irregularly replaced by black chert that may or may not be auriferous. As much as 30 pct of a vein may be calcite.

Usually the ore contains gold and silver in about equal parts by weight. No visible gold is present and the vein quartz is almost free of sulfides, so it is suspected that electrum is the valuable mineral.

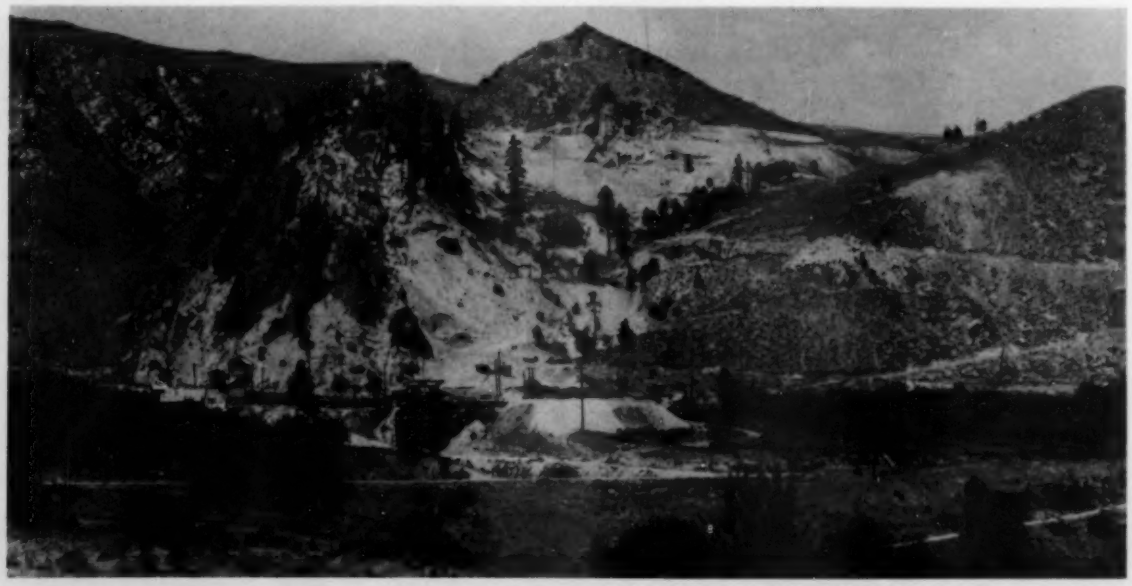
One small vein in the mine assays about 25 oz of silver and only 0.20 oz of gold per ton. Tiny nests of a silvery mineral that could be argentite can be distinguished through a lens.

The oxidized ore near the surface usually carries two to three times as much silver as gold by weight. This may be due to secondary enrichment or to an original conditions near the top of the orebodies.

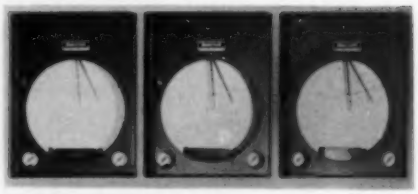
The sandstone country rock, particularly near the veins, is normally impregnated with fine pyrite that could amount to 3 pct by weight. Oxidation of the pyrite gives the sandstone outcrops a pronounced brown yellow stain.

CONCLUSION

This mine is still responding to development, and the geological picture suggests that it could continue to do so for many years. But the life of the mine may well be shortened if the non-controllable costs continue to mount with no compensatory increase in the price paid—a situation that has been strangling gold mining for the past 12 years.



Pinnacled mine formation of original workings is shown at center left. Younger sandstones dip away on each side.



INSTRUMENTATION AND CONTROL IN URANIUM MILLS

by C. M. MARQUARDT

The minerals industry in general should bow in homage to the uranium milling industry. Those in the uranium milling industry have "spark-plugged" more progress in the application of instrumentation and control in the last 5 years than has been made in 50 years by the industry in general. Part of this real progress in the application of instrumentation and control has been born of necessity because milling processes are more complex. A lot of the impetus for instrumentation and control has come from the fact that the industry is new, the processes are new, and there are no hide-bound conventions to overcome. Part of it comes from the fact that much of processing is more chemical than metallurgical and the thinking of the process chemist has carried over into the plants. One need not elaborate on what instrumentation has done for the process chemical industries.

Each new mill that is constructed, if of appreciable size, seems to employ more instrumentation than the previously completed plant. Plant A makes a break-through in the application of instrumentation to a particular part of the process and Plant B accepts this and goes one step farther, while Plant C, anticipating Plant B, makes two or three more steps before Plant B is entirely leveled out.

To the control engineer who has been hammering at these problems in instrumentation and control, this is most gratifying. Many of the things that the uranium industry is now doing have long been recognized by the control engineer as entirely practical.

The application of control devices in uranium mills generally can be paralleled to any other milling process with a minimum of effort. With the competitive situation in the industry rapidly developing, those companies in uranium that do not employ adequate instrumentation would be well advised to review their situation. There will certainly come the day when the milling plant with the minimum labor cost and maximum process control will be able to exercise its competitive advantage.

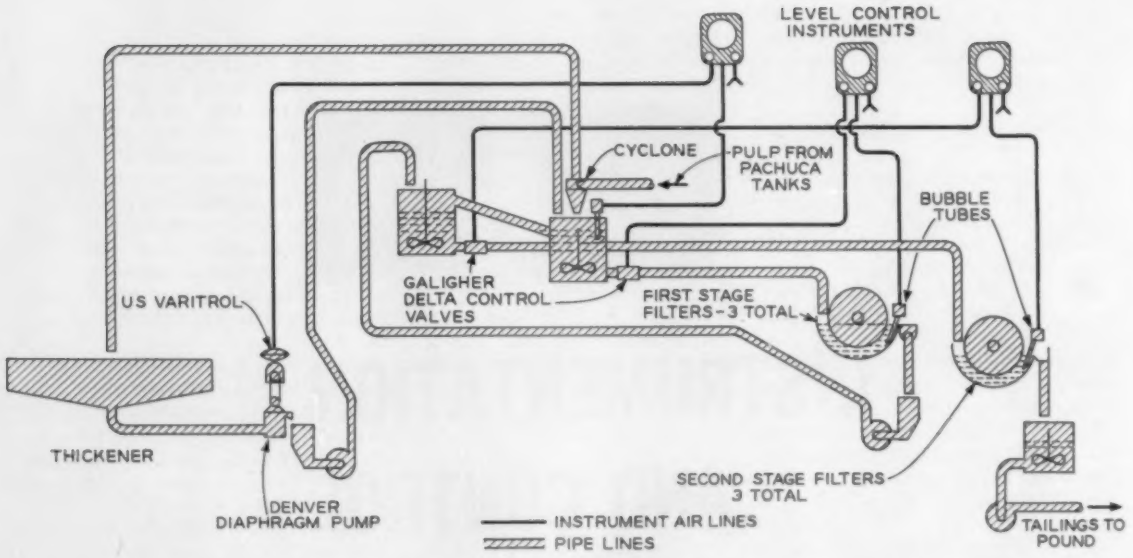
To illustrate application of instrumentation to the milling industry, this article will generally describe the instrumentation and control being employed at the recently dedicated Homestake-New Mexico Partners Mill at Grants, N. M. The author was privileged to be selected as consultant and designer and was ultimately responsible for placing in operation all the instrumentation that went into this fine new plant.

From the outset, the plant design was carried on with the application of automatic control devices in mind. The prime consideration was the application of instrumentation that would save labor and improve the process. Only such instrumentation as would accomplish these two prime purposes was employed. The application of enough instrumentation is highly desirable. The application of overly complex instrumentation can only result in confusion of the operator and loss of confidence in the more desirable instrumentation. This thing of instrumentation can be carried too far, as easily as inadequate instrumentation can be practiced.

OVERALL PATTERN OF CONTROL

On this project the purpose was to employ all of the usable instrumentation possible, and to leave to future instrumentation those portions of the process where the advisability of instrumentation was

C. M. MARQUARDT is President, Industrial Physics & Electronics Co., Salt Lake City. Third AIME Uranium Symposium, May 1958, Moab, Utah.



Homestake-New Mexico Partners Mill—Filter Section Pulp Level Control System

questionable. In order to make the operator's job easier, it was decided that in addition to the instruments for process control on the various panels, pushbutton stations would also be placed on the same panels. The basic idea was to give the operator not only the necessary instruments but also the means of controlling other factors in the process from these central control panels. There are five such panels employed in this milling operation.

Crushing: One such panel is in the crushing plant where the operator selects the various conditions under which he wishes to operate, and pilot lights show him what equipment it is necessary to operate to fulfill each of the three conditions of operation. First, coarse crushing, sampling followed by fine crushing, and conveying to the fine ore storage bin. Second, coarse crushing, sampling, and conveying to a truck bin for stockpiling samples and coarse-crushed ore. The third condition of operation involves the reclaiming of previously sampled ore from the stockpile. Under this condition there is only fine crushing and conveying to the fine ore bins. The operator, by means of a selector switch, chooses the equipment that is to be operated under each of the conditions. In addition, operation of the selector switch sets up the necessary interlocks.

Grinding: The second panel in this system of integrated mill controls is that employed in the grinding section. Here the ore is weighed and controlled using Con-O-Weigh pneumatic scales as it enters the ball mills, and a record is kept of the tonnage rate as well as integrated tonnage to each mill. Dilution in the ball mill is controlled by a flow recorder-controller on the panel for each ball mill operating a dilution control valve. Overflow specific gravity of the classifier is automatically maintained by a bubble-tube type of specific gravity controller operating a classifier overflow dilution control valve.

Pachucas: The classifier overflow is passed through a cyclone with the underflow going into an agitator tank and the overflow going to a thickener. A pulp density controller blends the thickener underflow with the cyclone underflow to maintain a constant specific gravity of material being pumped to the Pachuca tanks.

The maintenance of a constant feed to the ball mills coupled with constant specific gravity of material going to the Pachuca tanks in essence represents and maintains a constant flow of material to the Pachuca tanks, thus insuring a uniform contact time with the leach solutions in the Pachuca tanks.

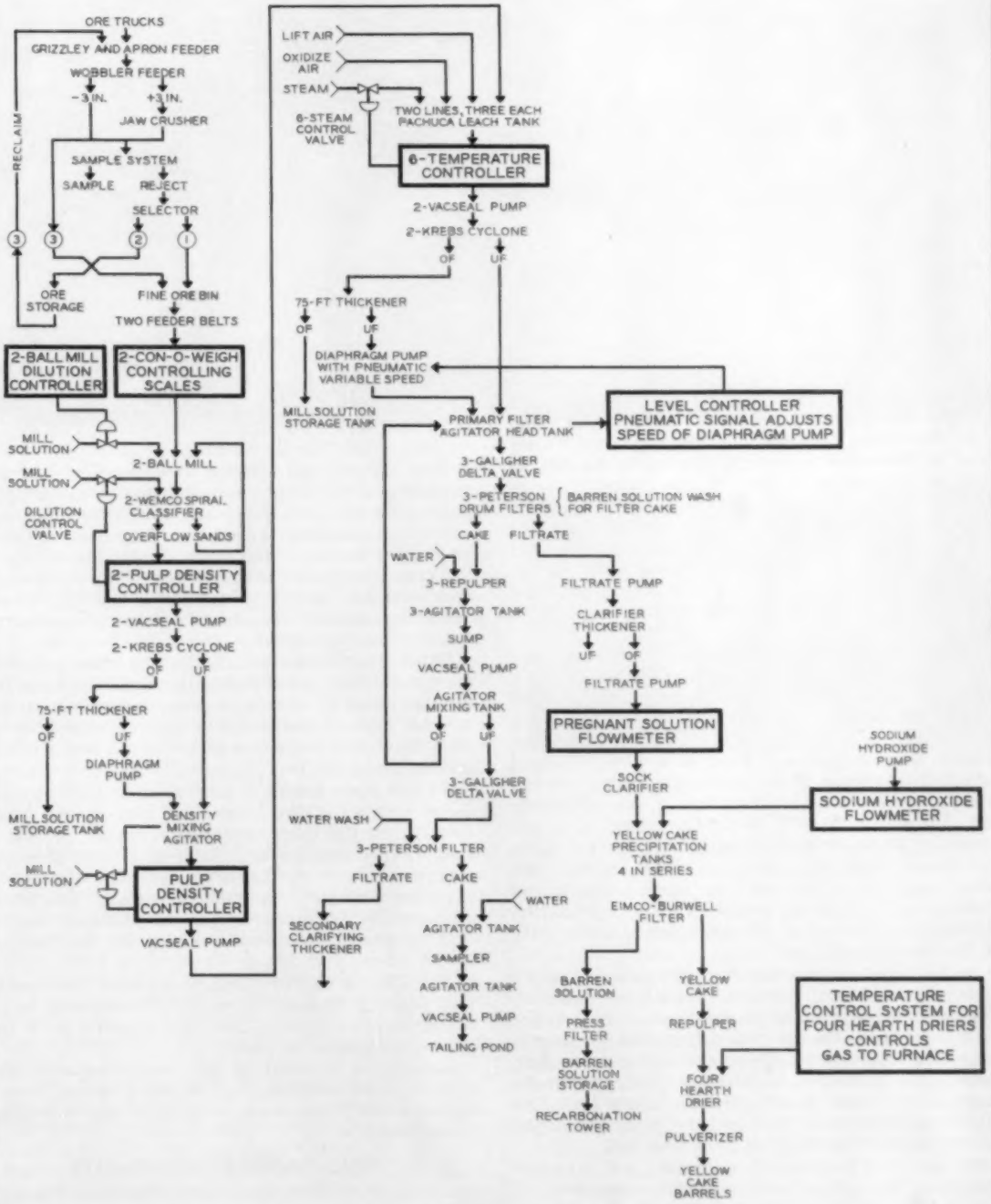
The overflow specific gravity of the Pachuca tanks is measured but is not automatically controlled. It was felt that control at this point was superfluous. There is a loss of solution in the Pachuca tanks due to evaporation at the elevated temperatures, and the manual addition to maintain a constant specific gravity of Pachuca tank overflow was more desirable than automatic control would be. In other words, the rate of change with a constant pulp flow is so slow that manual control was far more desirable at this point than automatic control.

The steam flow to each of the Pachuca tanks is automatically controlled to maintain a constant tank temperature but the amount of steam being consumed is not being measured. The basic problem is to maintain temperature, and the measurement of steam appears superfluous, except for accounting purposes. Air to the Pachuca tanks is not controlled.

The overflow of the Pachuca tanks is pumped to cyclones, the underflow of the cyclones going directly to the filters. The overflow of the cyclones is taken to a thickener which acts partly as a surge tank for the storage of the more slimy products but overflows a clear product to unclarified pregnant solution storage. This reduces filtration.

In every uranium plant of this type the expensive filtration section is generally the bottleneck. Because the cost for this section of the plant represents a large portion of the capital cost, its operation at the peak of efficiency is highly essential.

Filters: The filter control system employed at this application is unique and simple. The idea is to operate the filters at the peak of efficiency at all times. This is accomplished through the application



INSTRUMENTATION AT HOMESTAKE — NEW MEXICO, PARTNERS MILL

of level control in the filter tub. The cyclone underflow and the slime underflow from the thickener join in a tank. The level is measured in each filter tub by means of a simple bubble tube. The level is controlled in each tub automatically by means of a Galigher Delta valve on the bottom of the agitator tank and pneumatically operated from the pulp level controller.

The level in the head tank receiving the cyclone spigot and the thickener underflow is maintained constant by regulating the speed of the underflow pump on the thickener. If the filter can handle more than normal production, the speed of the thickener underflow pump is increased and the thickener is pulled down. If, however, a particular filter cloth has become "blinded" with slimes, the thickener underflow pump will be automatically slowed down to maintain a constant level in the head tank. Thus, under these conditions the filter will store the slime product. Of course, this cannot be kept up forever, but it does give several days of surge capacity when there are process difficulties.

The filtercake from the first filter is repulped and washed with barren solution and pumped to a second agitator tank beside the first agitator head tank, but it is set at a higher elevation than the first tank.

In the second filtration step, the level in the filter tubs is controlled in exactly the same manner as that in the primary filters. If the second stage of filtration is unable to handle the repulped product from the first stage of filtration, the second agitator head tank will overflow into the first agitator head tank, resulting in a decrease in speed of the thickener underflow pump. The system is thus balanced and there is a minimum of recycled product in the filtration process.

One of the distinct advantages of this particular filter control system is that it is possible to take a filter out of service for cleaning or replacement of filter cloth without reducing production. After a filter has been cleaned or a new cloth has been installed, the machine will filter at a very increased rate and by means of the automatic control system will take all of the product that it can efficiently use. Thus, if a filter is down for repair, it is not necessary to decrease mill production, for the slime will be automatically stored in the thickener, and when the filter comes back on stream, the stored slime product will be quickly removed from the thickener by reason of the increased filtration rate of the rehabilitated unit.

In this plant continuous precipitation with sodium hydroxide at 50 pct solution strength is employed. The pregnant solution is metered with a flow meter as it is pumped through the sock clarifiers and into the precipitation tanks. Using a rotometer-type flow meter, the hydroxide addition to the yellowcake precipitation tanks is automatically controlled. The filtered yellowcake is repulped and pumped into an automatically controlled four-hearth dryer.

Drying: The four-hearth dryer is quite uniquely controlled. By means of bias regulators the ratio of fuel fed to each hearth may be set on the control panel. The gas temperature in the third hearth is used as the basis for automatic control. A temperature profile is established from operating experience by means of the manual bias fuel flow regulators and then the third hearth controls the fuel supply to all of the four hearths, in accordance with the temperature on the third hearth.

Originally plans were to use the temperature of the final product as the means for control of all four hearths. However, it was soon found out that yellowcake is an excellent insulator and temperature of the final product could not be used as the control means. With the record of the four-hearth temperatures available from a strip chart recorder, it quickly became obvious that the gas temperature in the third hearth would prove an effective means of control.

When the plant was first placed in operation a Microdyne dust collector was employed in the hearth exhaust. It became necessary to control a tempering air damper to prevent overheating of the Microdyne dust collector. This was effectively accomplished, but after a few days of operation it became evident that the Microdyne dust collector had been improperly employed and it was removed. At the present time the hearth dryer is operating on a natural draft of about ⅛ in. of water.

Through the carefully controlled temperatures there is no burning of the yellowcake product and an extremely dense product is being produced. It is possible to put approximately 825 lb of yellowcake in each 55-gal drum. The produce iz being dried to practically zero moisture content and densification is further aided through the employment of a pulverizer on the hearth discharge product.

Originally it was planned to maintain a constant specific gravity of the product going to the tailings pond. This has proven impractical and the pulp density meter presently is not being employed. Of all of the instrumentation employed in this plant, this is the only instrument not being used. The instrument was installed for the purpose of conserving water, which is scarce in the area. To date its application has not been practical.

Other Plant Features: The milling plant is served by a well which is automatically controlled from the power house by means of a rather unique circuit scanner system, which allows many control and indication signals to be sent and received over a single pair of conductors.

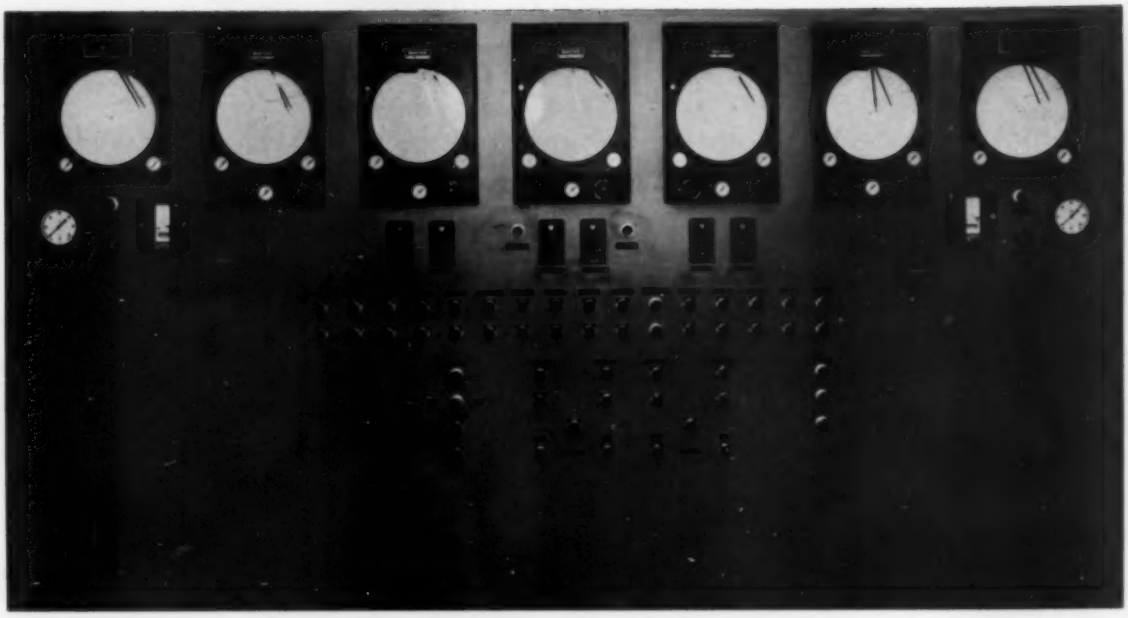
At this plant power is generated by 1000-hp gas-diesel engines of the locomotive type—three being installed in the plant, and two normally in operation. The diesel electric equipment is highly instrumentized so that it is necessary to have only one man on a shift to operate the power generation equipment, the compressors, the vacuum pumps, and the steam generators necessary for the Pachuca tanks.

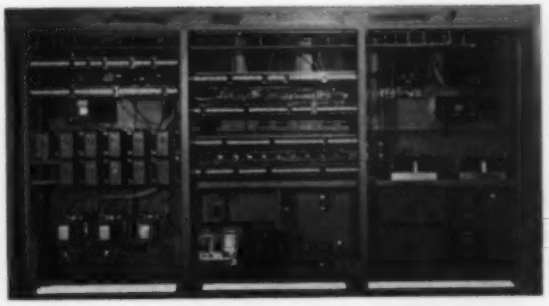
The plant is run by a minimum force, the operators keeping in touch through a widespread audio communication system that is independent of the plant's telephone circuits.

Largely as a result of the instrumentation and control employed, this plant is being operated with approximately two-thirds of the originally estimated manpower.

IDEAS FROM OTHER PLANTS

At the Dawn Mining Co. near Spokane, Wash., a unique application of belt scale weighing is being employed to good advantage. The idea is not entirely new, since it was first employed at the East Anaconda crushing plant of The Anaconda Co. Here two belt scales are employed on the same belt and the average of the two scales is used as the mill weight. These scales are periodically checked against very accurately weighed truck samples. The agreement between all the scales has been uniquely





Grinding Circuit Control Panel: *Two Con-O-Weigh controlling-belt scales (end dials); two flow recorder-controllers for maintaining flow of mill solution to ball mill feed (second from each end); two pulp density recorder-controllers for controlling classifier overflow pulp density (third from each end); pulp density recorder-controller for regulating specific gravity of pulp being pumped to pachuca leach tanks (center dial). All units are basically the same instrument. Note pushlight stations for starting, stopping, and indicating all remote equipment.* **Right (rear view):** *Note all interlock relays completely wired to conveniently located terminal strips, also convenient bulk head connectors at top of panel for all pneumatic connections. Panel completed, assembled, factory-tested before shipment. Only simple field connections needed.*

gratifying. The basic idea in employing two scales on a single belt is twofold. Belt weighing is a one-pass proposition. If the scales are out of calibration it is never known until the scales are checked. When two scales are employed, unless they agree within close limits of toleration, it can soon be determined that a scale is out of adjustment and recalibration is necessary. Secondly, the average, as obtained from two scales, is certainly a better measure of the true tonnage than the weight obtained from a single scale.

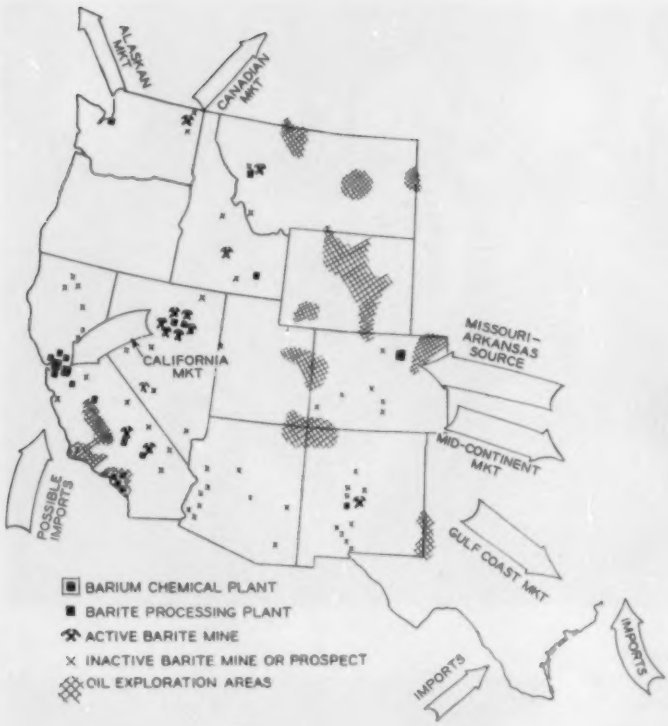
Here, the author believes, is an opportunity to effect some real savings in many uranium operations. The weighing of each individual truckload and sampling both for uranium and moisture are not conducive to the most accurate results. It is difficult to sample truck lots properly. It would appear to be in the interests of the industry for the AEC and industry engineers to re-examine this field.

In the ion exchange plant of the Dawn Mining Co. instrumentation is employed to maintain and meter solution flows, to ratio water to acid in the 6th and 7th steps in the elution cycle. At this plant in the precipitation cycle, pH is used to control the precipitation of gypsum and ferric hydroxide by automatically maintaining a pH of 3.3 to 3.6 by controlling the ammonia addition. Final precipitation of yellowcake is automatically controlled by controlling the ammonia addition to maintain a final pH of 6.8 to 7.0. At this plant the high nitrate product being discharged to tailings is metered, and so is the low nitrate product being returned to process.

It is interesting to note that though a great deal of instrumentation is being employed in the uranium mills, very little of it was specifically developed for the uranium mills. By and large it is a question of the application of known instrumentation to the processes. It is an excellent example of the application of the building blocks of the control industry to this field. It shows what control engineering can do to apply the instrumentation that is already available.

Engineers who are associated with the copper, lead, zinc and other branches of the minerals industry would be well advised to look at what is being accomplished in the uranium milling field as a means of reducing costs and helping to combat the effects of depressed metal prices. It is not being suggested that through application of instrumentation and control there will be a one-third reduction in labor costs, but what would a one-third reduction in labor costs do for your operation?

Economic Position of Western Barite Deposits



by W. C. PETERS

From the time of its beginning in the mid-19th century, the American barite industry has had its major development in the eastern and central states. Geologic and economic factors serve to maintain Arkansas, Missouri, and the Southern Appalachian states in the lead position. In earlier days, the major markets for barite were in paint, chemical, and glass manufacturing, and the favored deposits were those which were close to eastern industrial areas; furthermore, the eastern deposits were cheaply mined and required little or no beneficiation. In the last few decades, the use of barite as a weighting medium for muds in rotary oil well drilling has caused a great expansion in the industry, but the marketing picture is still centered outside of the western states—now on the Gulf Coast area where high pressures are common in oil wells. Low cost imported barite, readily available on the East Coast and Gulf Coast, has always been a major marketing factor in the industry.

The major barite producing state is Arkansas, with the industry centering about the Magnet Cove area. Missouri ranks second, with production mainly from residual deposits. Several Southestern states are actively producing from residual deposits.

Domestic reserves are sizeable. Total known recoverable reserves in the U. S. have been estimated to exceed 40 million tons of $BaSO_4$, about 60 pct in the Missouri-Arkansas area.

In the past few years, about one-third of the barite used in the U. S. has been imported. The main source of imports is Nova Scotia. Mexico is shipping large quantities into the Gulf Coast area, principally from mines in Coahuila and Nuevo Leon. Peru, Yugoslavia, Italy, Brazil, Greece, and Cuba have recently shipped barite to the U. S.

W. C. PETERS is Geologist, Mineral Development Dept., Chemical Divs., Food Machinery and Chemical Corp., Denver. AIME Pacific Southwest Minerals Conf., April 1958, San Francisco.

WESTERN DEVELOPMENT

The western states have not participated in the large Gulf Coast market because of the relatively low price for raw barite and the disadvantage of a long and expensive freight haul. Any continuing gap between supply and demand has been met by imports more cheaply than by western barite. Except for shipments during times of temporary barite shortage, the western barite industry has had to depend on the local market, principally in California.

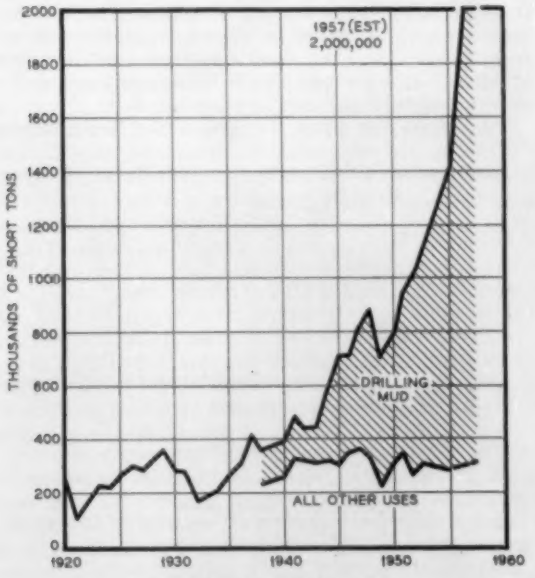
1910-25: Barite production from the western states was small and erratic, never exceeding 5,000 tons per year. The market consisted of paint and chemical plants in the San Francisco area and a chemical manufacturer for the sugar industry in Colorado. The major producing mines were near El Portal and in Nevada County, Calif. There was minor production from the Salinas area, Monterey County, and from San Dimas Canyon, Los Angeles County, Calif. Small shipments were made to California from Hawthorne, Nevada, from Cochise County, Arizona, and from Hailey, Idaho. Minor shipments were made to Denver from Custer County, Colorado, and to El Paso from the Las Cruces area, N. M.

1925-35: The demand for barite in the western states increased considerably, the major users still being paint and chemical manufacturers. Production from California climbed to 25,000 tons per year. In Nevada, minor production began from the important Carlin-Battle Mountain area. Shipments were made from Coon Bluff, near Meza, Ariz.

By the mid-1930's the use of barite in oil well drilling had become the most significant factor and has dominated the market ever since. This increase in demand was felt most strongly in the southern states. Although western barite production was stimulated, it did not climb so rapidly as total national production. Nevada began to account for an increasing percentage of western production and, shortly after World War II, surpassed California. During the 1930's and 1940's, minor amounts of barite were mined in Arizona, Colorado, Idaho, and New Mexico. The most significant developments outside of the Nevada-California region were at Coon Bluff, Ariz., and in the Hansonburg district, Socorro County, N. M. The latter deposit was in a favored position because of its relative accessibility by rail from the Gulf Coast and because of its additional revenue from lead and silver ores. Production from the western states during the 1940's reached 100,000 tons.

1945-58: The present period has seen a marked rise in demand for barite in all parts of the country. The largest demand, in the deep and high-pressure oil wells of the Gulf Coast, has not had any sustained influence on the major western producers except in the case of Arizona, and New Mexico, where the Gulf Coast has sometimes shared the market with western oil fields. Several moderately large barite mines are operating in Nevada and California. The Battle Mountain area supports several crushing plants and a mill. In New Mexico, the Hansonburg district is active. The Sun Valley mine near Hailey, Idaho is shipping barite to mud companies in the Rocky Mountain area. New barite producers near Addy, Stevens County, Wash., and near Greenough, Missoula County, Mont., have shipped mud-grade material into the Rocky Mountain area of the U. S. and Canada. Colorado has a few small and sporadic producers for the mud and sugar-chemical industries. The Coon Bluff deposit in Arizona has been virtually mined-out and is no longer a producer.

The western states mined about 260,000 tons of barite in 1956, or about 19 pct of the total U. S. production. Nevada is the leading western state,



Barite—Total U. S. Consumption

Barite—U. S. Production

and ranks third in the U. S., most of the production coming from half a dozen mines in the Battle Mountain area.

In the western states, geologic conditions dictate mining methods which differ markedly from those in the East. There are no economic concentrations of residual barite. The most widespread type of western occurrence is in veins, typified by the formerly productive barite deposit at Coon Bluff, near Mesa, Ariz. Of more economic importance but less common distribution, are massive fine-grained bodies in shale or limestone, as in the Battle Mountain area, northern Nevada. Vein deposits are commonly narrow, irregular, and of complex mineralogical nature, with the accessory minerals representing an additional separation cost. In the case of the Hansonburg, N. M. deposits, accessory minerals are a source of additional revenue. Mining methods and costs in the Western states are of considerable variety. Open pit mining is generally used, with the cost of removing hard overburden limiting most operations to shallow depth. Underground mining is limited to low cost methods, such as open stoping and shrinkage stoping. Until very recently, much of the barite mining in the West was exclusively for high-grade material requiring little beneficiation beyond screening. The trend now, as in the East, is toward development of larger and lower grade reserves for beneficiation by jigging, flotation, and air separation. In open pit mines with little overburden and situated close to tail, high-grade can be loaded at rail points for costs on the order of $5.00 to $7.00 per ton. Very few western deposits remain in this category. Such additional costs as preliminary concentration and long truck haul bring most costs in the western states up to the $9.00 to $12.00 level, which compares with a $10.00 to $14.00 range for costs in the Southeast and Missouri. Some Nevada barite is hauled 40 miles to rail. Some potentially attractive deposits are 60 to 80 miles from rail and in relatively rugged country.

In short, some western barite deposits have a slight advantage in mining cost over eastern deposits. That advantage is lessened by the common requirement of a long truck haul and by the gradual elimination of the higher-grade deposits. Remoteness of the deposits from the eastern market is the controlling factor in prohibiting widespread competition with eastern and imported barite.

As indicated in Fig. 3, 70 to 80 pct of total U. S. consumption of barite is used in oil drilling muds. The major requirement is for weight, which serves to prevent gas, oil under high pressure, or salt water

from blowing out of the bore hole. Mud grade barite requires a specific gravity of at least 4.2 (about 94 pct $BaSO_4$). In some of the western oil fields, where pressures are low, a specific gravity of 3.9 is acceptable at a reduced price. Soluble salts such as calcium sulfate are objectionable in that they tend to flocculate bentonite, which is also a component of drilling mud. The delivered product at drilling sites must be ground to 200 mesh or finer. The weight of the resulting mud is variable, but averages from 13 to 16 lb per gal. The maximum density that can be obtained by weighting muds with barite is about 22 lb per gal.

USE AND SPECIFICATIONS

Aside from drilling mud, barite finds use in a wide variety of industries, most of which have been developing at a fast rate. Substantial quantities of barite are sold to the chemical industries and paint and glass manufacturers. Recently, some has been sold to manufacturers of an additive for asphalt road construction. Ten years ago, the market for chemical grade barite was about equally divided between chemicals and lithopone. Lithopone, a mixture of zinc sulfide and barium sulfate used as a pigment, has lost ground to titanium dioxide, and there is every indication that titania pigments will continue to replace lithopone. Decreasing lithopone manufacture has been offset by increased demand for barium chemicals in a large number of other industries. The demand from the chemical industry, while significant and expanding, is greatly overshadowed by the present demand for drilling mud.

Specifications for chemical grade barite call for a high quality product, with more than 92 pct $BaSO_4$ and with very small amounts of iron oxide, strontium sulfate, and fluorine. Low limits on strontium minerals and fluorine are very important to the mine operator inasmuch as celestite and fluorite are commonly associated with vein-type barite deposits.

The use of a barite-rubber additive in asphalt highway construction is in an experimental stage; if successful, it would create a boost in demand as the Federal highway construction program gets under way. A few percent of the additive in hot mix road asphalt has been tested for a few years and, if the additive finds general use, this market could equal that of the chemical industry. Specifications for barite in the asphalt additive are rather broad and it is expected that impure baritic mill tailings from metal mines can be utilized.

The use of barite in aggregates for concrete shields employed in protection against nuclear radiation may be expected to expand. Increased use of barium metals and alloys is expected in various applications.

MARKETING

Although average prices for barite are given in the major mining magazines, the actual price is largely a matter of negotiation between buyer and miner. Crude imported barite, the dominating factor, is quoted at $16.00 to $18.00 per short ton, c.i.f. Gulf ports, subject to a duty of $2.70 (long ton). A tariff of $7.50 per long ton on ground barite makes it economically preferable to import the material in the crude state. Throughout the country, prices for crude barite may be a few dollars lower or higher, the governing factors being grade of the material and distance between mine or port and market. On the West Coast, crude barite sells for around $17.00 per ton, the price being a function of rail haul from mines in Nevada and California. Barite which is ground and bagged in the mining area brings an increment in price of $6.00 to $8.00 at the shipping point, this price representing the cost of preparation. Barite for the chemical industry generally brings a price similar to that used in drilling mud except in the case of especially ground, bleached, or processed material which may bring prices up to $45.00 per ton, f.o.b. works.

The price of ground and bagged mud grade barite delivered to the drilling site is in the neighborhood of $40.00 to $60.00 per ton, depending upon the location. The price differential between raw barite and the delivered product represents technical services, sales commission, warehousing, and freight. Marketing of barite is, therefore, a dominating factor in the final price. The sale of barite mud and all types of drilling media is highly competitive and is as much an engineering service as a sale of material. Very few drilling companies supply their own mud; they find it much more convenient to depend upon the facilities of a mud company in furnishing whatever medium is required at any time and in any locality. Furthermore, the highly specialized and costly supervision and service which attends use of drilling mud is taken into account. The mud company is required to keep personnel, stock, and transportation ready for any emergency, as in a recent instance in which barite was reportedly flown from Canada and the West Coast to a drilling site in Alaska where a well was in danger of being damaged by rapidly developing pressure.

The dominant price factor on the Gulf Coast,

Table I. Barite Milling and Chemical Plants—Western States

Barstow, Calif.:	Oil Base Inc.:	Beneficiation and grinding plant for drilling mud.
Berkeley, Calif.:	Alloys Div.:	Grinding plant.
	Industrial Minerals & Chemical Co.:	Grinding plant.
Compton, Calif.:	Oil Base Inc.:	Grinding plant.
Emeryville, Calif.:	Yuba Div., Metals Disintegrating Corp.:	Grinding plant.
Fresno, Calif.:	Fresno Agricultural & Chemical Corp.:	Grinding plant.
Harbor City, Calif.:	Calada Minerals Co.:	Grinding plant.
Los Angeles, Calif.:	American Minerals Co.:	Grinding plant.
	Kennedy Minerals Co.:	Grinding plant.
Merced, Calif.:	Baroid Sales Div., National Lead Co.:	Beneficiation and grinding plant for drilling mud.
Modesto, Calif.:	Barium Products Ltd. (Westvaco Mineral Products Div., Food Machinery & Chemical Corp.):	Barium chemical plant.
Oakland, Calif.:	Chemical & Pigment Co.:	Lithopone plant.
Rosamond, Calif.:	Macco Corp.:	Grinding plant for drilling mud (milling plant at mine in Nine Mile Canyon).
San Francisco, Calif.:	Commercial Minerals Co.:	Grinding plant.
Johnstown, Colo.:	Great Western Sugar Co.:	Barium chemical plant for beet sugar industry.
Pocatello, Idaho:	J. R. Simplot Co.:	Grinding plant.
Greenough, Mont.:	Baroid Sales Div., National Lead Co.:	Jigging and grinding plant.
Battle Mountain, Nev.:	Magnet Cove Barium Corp.:	Beneficiation and grinding plant for drilling mud.
Beowawe, Nev.:	Yuba Milling Co.:	Grinding plant.
San Antonio, N. M.:	Mex-Tex Mining Co.:	Beneficiation plant for producing barite from lead-silver ores.
Seattle, Wash.:	Manufacturers' Mineral Co.:	Grinding plant of drilling mud.

where approximately 85 pct of the drilling mud is consumed, is the cost of imported barite versus the cost of barite from Arkansas, Missouri, and the southeastern states. With duty and freight paid, the price is in the neighborhood of $20.00 to $25.00 per short ton from any of these sources. One of the main factors governing the consumption of foreign barite is a wide fluctuation in ocean freight rates. Inventories can be built up most economically when shipping rates are low.

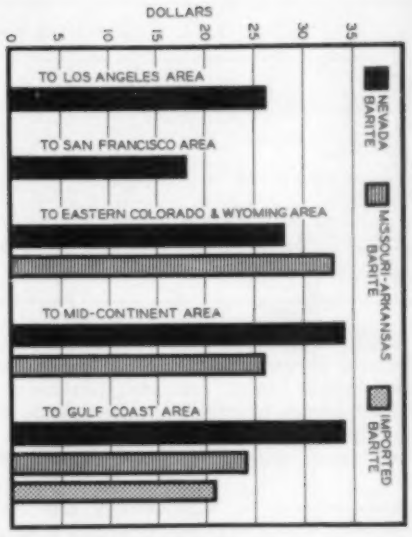
At the present time, drilling of new wells is somewhat curtailed and the demand for barite in the Gulf Coast area is amply met by low-cost domestic production and imports. A short time ago, when drilling in the high-pressure offshore area was at a maximum and an international oil shortage was looming due to the closing of the Suez Canal, barite was in short supply on the Gulf Coast and shipments were brought in at premium price from Nevada, Arizona, and the Rocky Mountain area. Similar shortages had developed before and will probably occur again, but under normal conditions barite is supplied to the Gulf Coast by the central and eastern States and by imports. In contrast to the usual sources of barite for the Gulf Coast, Nevada barite can be delivered only at costs from $29.00 to $34.00 per ton, about $23.00 of the cost being in rail freight, with no provision for profit. Barite from smaller producers and potential producers in New Mexico and Colorado could be shipped to the Gulf Coast market at about $25.00 per ton, considering the most favorable mining conditions and the most favorable rail rates.

About five percent of the barite-drilling mud used in the United States is required in the West Texas and Mid-Continent fields. New wells are relatively shallow and are not subject to such high pressures as in the Gulf area. Barite prices are established by producers in the central states and, to a lesser extent, by imports. In this area, barite from Arkansas and Missouri can be delivered at a cost of $22.00 to $26.00 per ton. Nevada barite would cost $28.50 to $33.50 per ton. Barite from New Mexico can be delivered in the West Texas oil area at a competitive advantage. In times of shortage, barite has been shipped to the West Texas and Mid-Continent areas from several western mines, the governing factor being a diversion of Missouri-Arkansas barite to the Gulf Coast.

The western market for drilling mud is chiefly in California, Colorado, New Mexico, Wyoming, and Montana, and is limited to 8 or 10 pct of the U. S. total. The controlling price factor here is availability of western barite. Imports have not become a factor in western barite markets as yet; it is significant, however, that ocean freight rates for barite from western Mexico and Peru to Los Angeles are nearly competitive with rail rates from northern Nevada. If a sudden demand for barite were to develop on the West Coast, imports would become a factor in maintaining the price near its present level.

The marketing area for Nevada barite, in direct competition with Missouri and Arkansas material, extends eastward to the oil basins of eastern Colorado and Wyoming.

In the active oil drilling areas in the western states, barite comes from major producers in Nevada and from minor producers in more favorable geographic situations. New Mexico barite is shipped at a profit to the nearby San Juan and Permian basins. Montana barite is in a good economic position for serving the Williston basin of Montana and North Dakota. Idaho barite is accessible at an advantage to the Wyoming oil fields and to the various oil basins in Colorado, Utah, and Montana.



Nevada vs Eastern Barite
(Production cost plus freight)

Some barite has been shipped from Washington and Montana to the oil fields in western Canada. Barite is, however, available in western Canada and deposits are being developed in British Columbia. Increased drilling activity in Alaska is expected to provide a market for western barite.

FUTURE OF WESTERN BARITE

Future developments in the western barite industry may in part be projected from known factors such as the geology of existing deposits, the status of developed reserves, the availability of imports, and the projected growth in demand from the chemical industry. There are several flexible factors which are of major importance, the largest and least predictable being the future requirement for drilling mud in the western states. New industrial uses, substitutes for existing applications, and conservation of existing supplies are also important factors and are difficult to forecast.

Supply: Many western barite occurrences are in narrow and complex veins. There are literally hundreds of bodies in such baritic regions as northwestern Arizona, Central New Mexico, and southern California; taken together, they constitute large quantities of barite but very few can be classed as reserves under existing or immediately projected economic conditions. Massive and bedded barite deposits are less common, but they include most of the actual reserves in the western states. Northern Nevada contains a large number of undeveloped massive and bedded deposits.

Low-grade and byproduct potentialities have not been fully considered in the generally accepted total of 40 million tons reserve for the United States. Byproduct sources may find increasing utilization in the future. Barite gangue is quite common in fluorspar, lead-zinc, and silver bodies. A barite byproduct is being shipped from the complex ore deposits of the Hansonburg district, New Mexico, and plans are being made to produce a barite byproduct from ore deposits near Spillama-

Table II. Operating Barite Mines (1956-1958) Western States

Barstow, Calif.:	Oil Base, Inc.:	Open pit mine.
Nine Mile Canyon (Inyo Co.), Calif.:	Macco Corp.:	Open pit mine.
Hailey, Sun Valley Mine, Idaho:	J. R. Simplot Co.:	Open pit mine.
Greenough, Mont.:	Baroid Sales Div., National Lead Co.:	Two underground mines.
Argenta Mine (Battle Mt. Area), Nev.:	Barium Products Ltd.:	Open pit mine.
Argenta Area, Nev.:	Shelton & Shelton:	Open pit mine.
Basalt, Nev.:	Kelly & Clark Mining & Exploration Co.:	Open pit mine.
Bateman Canyon Mines (Battle Mt. Area), Nev.:	Barium Products Ltd.:	Open pit mine.
Carlin Area, Nev.:	Three small lease operations.	
Dunphy (Rossi Mine Area), Nev.:	Baroid Sales Div., National Lead Co.:	Open pit mine.
Greystone (Battle Mt. Area), Nev.:	Magnet Cove Barium Corp.:	Open pit mine.
Mountain Springs Mine (Battle Mt. Area), Nev.:	Barium Products Ltd.:	Open pit mine.
Hansonburg District (Socorro County), N. M.:	Mex-Tex Mining Co.:	Underground mine.
Addy (Stevens Co.), Wash.:	Manufacturer's Mineral Co.:	Open pit mine.
Colville, Wash.:	Sunshine Mining Co.:	Under development.

cheen, British Columbia. There are a large number of additional deposits from which barite could be recovered under better economic conditions. One unexploited source of barite in the gangue associated with rare earth minerals at Mountain Pass, Calif., represents several million tons of developed reserve.

Barite, because of its high density, offers an opportunity for relatively inexpensive gravimetric prospecting. If a large market for barite develops in the western states, geophysical work will greatly assist in locating new reserves.

Foreign reserves are known to be large and should continue to be imported into the Eastern states at a cost below that of western barite. Similarly, foreign barite, especially from South America and Mexico, would become a factor in the West Coast market if the price were to increase. With cheaply mined and high-grade domestic barite being exhausted at a fast rate, imported barite could become a dominant source of supply unless technical and economic problems can be solved for utilizing low-grade and byproduct deposits. If, by some chance, import duties were raised, foreign barite would relinquish its advantage and western barite might find an increasing market. The Missouri-Arkansas area would still be in a better position than the western states in regard to marketing.

Demand: The use of barite in chemical manufacture has risen sharply in the last few years and is expected to continue its trend. From 1950 to 1955, chemical use for barite increased about 45 pct. Much of the demand is from California, which depends on western sources.

Many of the minor uses for barite are important and will account for an increased demand in western industrial areas. The largest use, in oil well drilling, is expected to continue its increase and will probably control the market for some time to come. Deeper drilling, with attendant higher pressures, is expected in nearly all petroleum exploration areas. The geographic distribution of demand for barite in oil well drilling is not favorable at present for western barite producers, but the oil exploration picture is subject to very rapid change and a new field in the western states with high gas or oil pressure could skyrocket regional demand.

In the field of drilling muds, barite, by reason of its high specific gravity, low cost, softness, cleanness, and inertness, is by far the most desirable of all weighting materials. Celestite has been used as a weighting material and some attempts have been made to use iron ore, but in each case there has been some major disadvantage. Mud weights up to 30 lb per gal have been obtained with galena, but the cost is prohibitive. Artificial weighting material may someday come into use; however, there is no present indication of what the substitutes would be or how their cost might compare with that of barite.

A significant percentage of the barite used in deep oil well drilling may be conserved by purifying the muds which return to the surface during circulation. A step in this direction has been reported at a deep hole site in Louisiana, where a liquid cyclone recovery system greatly reduced barite usage. Mud left in the hole when casing is set and tubing is run cannot be recovered; this is commonly 50 or 60 pct of the total mud in the system.

The writer wishes to thank O. W. VanDyke, W. E. Gorham, and Donald Brobst for reviewing and commenting upon an earlier draft of this paper.

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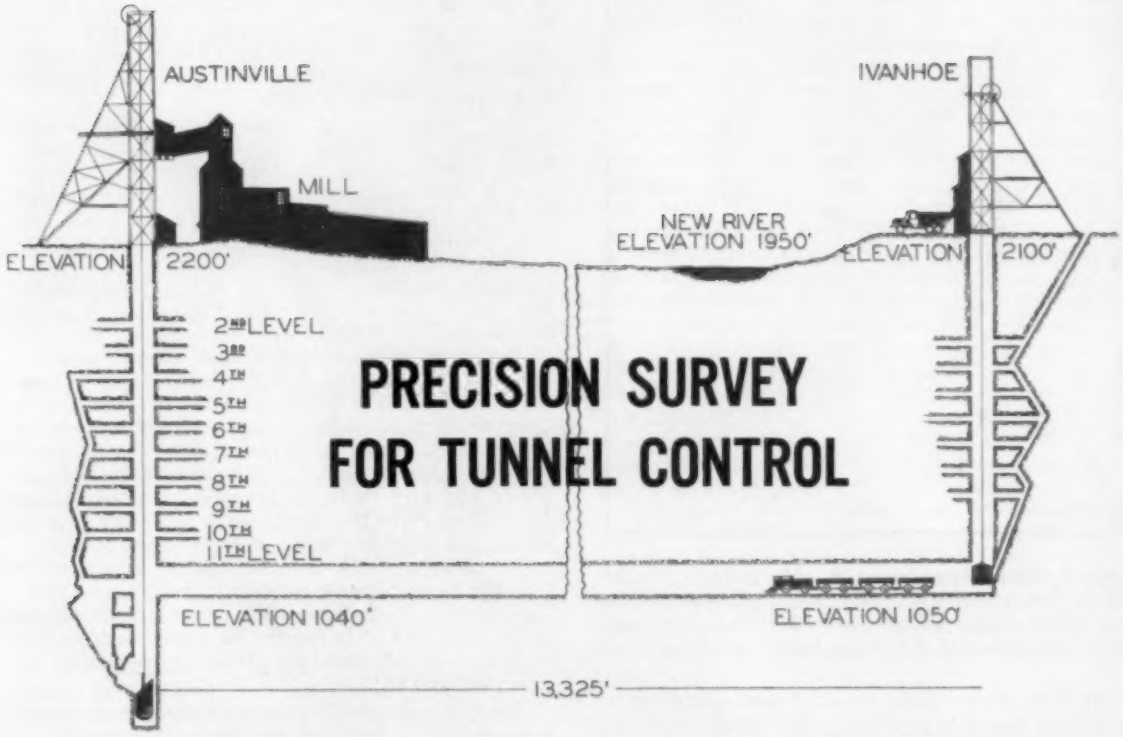

PRECISION SURVEY FOR TUNNEL CONTROL

by DOUGLASS D. DONALD

The New Jersey Zinc Co. successfully holed through a 2½-mile haulage tunnel connecting its new Ivanhoe shaft with the Van Mater Shaft at Austinville, Va. This 8 x 10-ft cross-section tunnel was driven from both ends and met at a point approximately a mile from one shaft and a mile and a half from the other. In order to make certain that the faces met accurately on line and grade it was necessary to refine conventional mine surveying practices.

The mines that are serviced by these shafts are located in the southwestern part of Virginia approximately midway between Roanoke and Bristol at the west foot of the Blue Ridge. While the presence of lead-zinc sulfide ores has been known in this area for more than 200 years, it was in 1902 that New Jersey Zinc Co. acquired the Austinville property, which has been in constant operation since that time. About ten years ago the company undertook an extensive diamond drilling program at Ivanhoe several miles to the southwest. This program was successful in locating sufficient ore to justify the purchase of a number of the properties in this area and plans were made to develop the new orebodies. The discovery of this ore as well as substantial additional reserves at Austinville resulted in a decision by the company to increase its daily milling capacity to 3000 tons, of which about 1000 tons would be supplied from the Ivanhoe mine.

After careful consideration of all possible methods of transporting this volume of ore from Ivanhoe to the mill, it became evident that diesel locomotive haulage through a 2½-mile tunnel between the two mines would best suit prevailing conditions. Since the lowest operating level, known as the 1100 level, of each mine would be at approximately the same elevation, it was obvious that such a tunnel should be driven on this level. Not only would this tunnel facilitate feeding Ivanhoe ore into the underground crusher and skip loading installation at Austinville, but it would also open up a known orebody 5000 ft southwest of the Van Mater shaft. In addition it would provide a valuable diamond drilling base from which a large and a potentially favorable but untested block of ground might be explored. In order to hasten the completion of the tunnel, it was felt that it should be driven from both ends.

ENGINEERING CONTROL PROCEDURES

It was vital that the tunnel junction be made accurately on line and grade; thus it was felt that engineering control of an unusually high degree of reliability was required to prevent an accumulation

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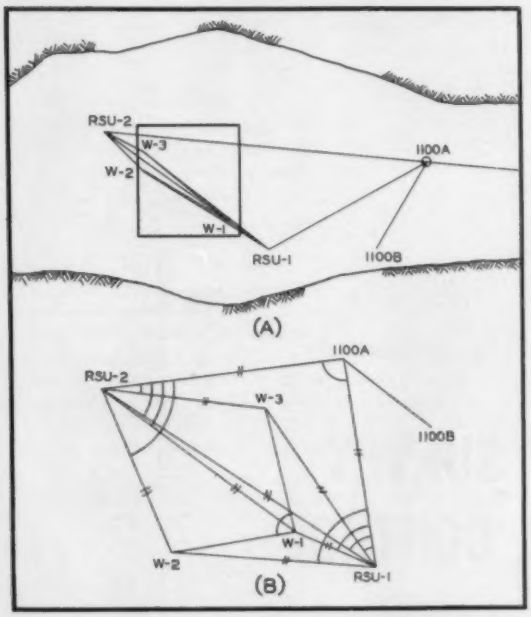
The Transactions papers appearing in MINING ENGINEERING *during 1958 will subsequently appear in AIME Transactions Vol. 211, and may be permanently referenced to that volume.*



Layout sketch shows setup at 1100 level of Ivanhoe Shaft. Lower diagram shows details of triangles used for taking control off at the station level. Arcs show observed angles and the double barred lines were taped.

of errors. Otherwise a sloppy tunnel closure if not a very embarrassing situation could result. A review of preexisting surface and underground engineering control showed small but significant discrepancies which could seriously affect the whole project. It was, therefore, decided that only by establishing a whole new control system would it be possible to have confidence in the success of the tunnel closure. Since there was no room for blunders or systematic errors in the primary control circuit it was important that all segments of the circuit be designed so that they could be easily checked for accuracy and precision. Thus the triangulation net was laid out so that all stations could be occupied in order to close each triangle. Triangles having an angular error of closure in excess of 5″ were resurveyed. Actually the maximum angular error that was distributed in any single triangle was 2″.

Elevation control was carried as a series of closed traverses and a maximum error of closure of 0.01 ft was considered acceptable, although in practice the error was usually 0.005 ft or less. Horizontal control in the tunnel was carried as a series of overlapping closed traverses ranging in length from 1500 to 4000 ft. Minimum standards of precision for linear closure were taken as 1 part in 30,000 and 15″ for angular closure. The errors in all acceptable traverses were distributed.

In order to meet these standards it was necessary to adopt certain procedures for taking the necessary measurements. All angles were measured using a mining transit with a 5½-in. horizontal circle graduated to 30′. Using a vernier direct readings could be made to 1′, although with a certain amount of care readings could be estimated to 15″. In triangulation work and shaft plumbing each angle was turned 12 times, 6 times to the right followed by 6 times to the left, alternate shots being taken with the telescope inverted. In order to fully benefit from the increased precision obtained by repetition, the plate was not reset after taking the first angle. Underground angles were turned four times, twice right and twice to the left again, inverting the telescope on alternate shots.

The commonest systematic error that might creep into the engineering control system could result from improper tape calibration or correction factors. Although catenary and tension corrections could be arrived at on a theoretical basis, it was felt that greater accuracy would be achieved by obtaining these corrections experimentally. It was therefore decided to establish a tape standardization range in an inactive part of the mine. A series of nine spads 25 ft apart were set in line in the back of the drift, with an extra spad placed midway between the 100 and 125-ft spads. Using a tape which had recently been standardized over a distance of 100 ft at 10-lb tension using end suspension by the U. S. Bureau of Standards, the distance between the spads from 0 to 100 ft and between 100 and 200 ft was very carefully determined. Once having determined these true distances, it was very easy to determine experimentally the combined catenary and tension corrections to be applied to a specific tape for measurements ranging from 12½ to 200 ft. The practice of applying 10-lb tension on distances up to 100 ft and 20-lb tension for distances from 100 to 200 ft was adhered to at all times, see figures on pages 980 and 981.

The first high precision taping traverse was measuring a 1000-ft base line for the surface triangulation net. Initially this was done according to U. S. Coast and Geodetic Survey specifications using the ventional four or five-man crew, but due to lack of experience it was found very difficut to hold the tape steady long enough at exactly the proper tension to obtain good readings. It was then decided to substitute two adjustable taping stands for the human tape holders in order to insure that the tape would be completely steady while measurements were being taken. One stand merely held the tape while the tension was applied at the other stand by means of a calibrated weight acting over a relatively large diameter sheave, thus reducing friction effects. The tape was read directly to 0.01 ft and estimated to 0.001 ft and readings were always taken at random on the tape rather than starting with a specific setting at one end of the tape. Two separate sets of readings were taken with different tape settings before moving to the next course and each reading was taken independently by each of the engineers carrying out the traverse. Comparison of the results of the two sets of tapings was made and if they corresponded closely enough they would move on to the next course.

Once this procedure had been adopted the base line measurements were carried out quite rapidly and a precision of somewhat better than 1 part in 800,000 was obtained. This was considerably more precise than the minimum requirements, which had been set at 1 part in 500,000.

Since this procedure worked so well on the surface, it was adapted to use for taping along the 1100 level. Track-mounted taping stands were made and worked especially well, since one of the permanent rails was laid directly beneath the engineering control points. Recording procedure was simplified by

having single readings made on each of three tape settings in order to reduce the probability of transposition of figures. If the spread of the three measurements did not exceed 0.003 ft their average was accepted.

It was found that underground control was best carried in three steps, one during which only the angles were turned, another measuring the distances and a third carrying vertical control. Since the ends of the tape were leveled when measuring distances, it was usually found convenient to combine taping and vertical control in a single step. The use of self-illuminated plumb bobs was a great help in expediting the angular traverses and the new taping methods enabled the engineers to measure distances precisely and rapidly. Once the procedures had been worked out it was possible for two engineers to complete about 500 ft of traverse per day.

SHAFT PLUMBING

Shaft plumbing has long been one of the most challenging problems to be faced by the mining engineer. There have been a great many ingenious methods devised for transferring engineering control down a vertical shaft, and one of the most complete summaries of different methods is contained in a series of articles by W. H. Wilson.[1] Peele's Handbook,[2] one of the more readily available reference books, briefly describes many of the basic plumbing methods.

For purposes of simplification, shaft plumbing may be resolved into two basic elements—first, transferring two or more points from the surface to underground and second, tying these points into the control system. Optical methods of transferring points down a shaft have long been used but are limited to relatively shallow shafts where the level to which the control is being taken can be clearly observed from the collar. The 1100 level in the Van Mater and Ivanhoe shafts was approximately 1050 ft below the collar and there was considerable water falling in each shaft, so optical plumbing was not feasible. Thus it became apparent that control points would have to be transferred by plumbing wires, but this method posed the problem of how to obtain accurate observations on wires that were constantly affected by the falling water and unavoidable air currents. Due to these factors it was felt that only by multiple observations on a swinging wire could a point be accurately established underground. Simple damping of the wire oscillations by immersing a medium weight plumb bob in a bucket of water was thought to be most effective, since more elaborate methods would only lengthen the required observation time.

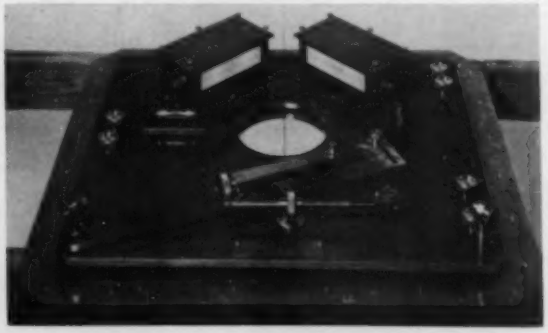
In plumbing a South African shaft[3] a simple device used for steadying the plumb wire seemed suited to the problem at hand. Accordingly the Engineering Staff at Austinville drew up the plans for the Bertha shaft plumbing device using some of the principles of the South African device plus modification and refinements to better suit conditions that would be encountered in plumbing the Van Mater and Ivanhoe shafts. The Research Dept. of New Jersey Zinc Co. modified these plans and fabricated the instrument as shown in the accompanying photograph.

Once a satisfactory method of transferring control points underground had been determined, it was not too difficult to decide how to tie these points to the surface and underground control system. Coplaning, or "jiggling in" as it is more commonly referred to, was considered, but it was not felt to be sufficiently accurate. A direct method of incorporating one of the control points in the triangulation net and setting the transit over this point to survey directly in the other control points proved most effective as a means of tying the control points at the surface to the triangulation net. For reasons to be discussed later, this method was also used to take control off on the 1100 level at the Van Mater shaft. The use of Weisbach triangles seemed to be the best underground method for Ivanhoe. The late Professor Henry Briggs presented a mathematical analysis of the Weisbach triangle,[4] in which he demonstrated that the effects of linear errors of measuremnt are not as critical in obtaining accurate results as the angular error provided that the triangle is established to conform to the following conditions insofar as possible: The distance between the two wires is large, the ratio of the distance between transit and the near wire to the distance between wires is as small as possible and the acute angle at the transit between the two wires is small, preferably less than 25′.

A method of using three wires in the conformation of two Weisbach triangles back to back was described in an article by I. M. Marshall,[5] and had the added advantage of providing an excellent check on the accuracy of the plumbing. It was thus decided to use this three-wire method and add to it a second transit set-up as shown in the layout sketch.

Plumbing the Ivanhoe Shaft—Surface Control: Referring to the layout, W-1 is a station in the surface triangulation net. It consists of a small hole drilled in the top deck of the Ivanhoe headframe selected so that a wire could be passed to the 1100 level clear of all projections. From this station a triangulation station in the Van Mater headframe could be sighted some 13,154 ft to the northeast. The location of W-1 was transferred from the top of the headframe to the collar of the shaft where a notched steel trap was welded in place, thus giving a point from which a plumbing wire might be suspended. From this collar position of W-1, W-2 and W-3 were carefully surveyed. These points were also steel straps welded to shaft collar steel from which wires could be suspended. In practice W-2 and W-3 were only about 2 in. apart and about 12 ft from W-1, and the angle W-2, W-1, W-3 was found to be 0°-37′-56″ accurate to plus or minus 3″.

Transferring Points Underground: Plumbing wires were lowered, one near W-1 and the other



near W-2. No. 10 gage (0.024-in. diam) piano wire was used with a light weight attached to the end of each wire. After the wires reached the 1100 level the wire reels were secured in the headframe and the wires were placed in the notches of the plumbing straps. The light weights were replaced with 20-lb plumb bobs (each consisting of a short piece of I-beam with a hole drilled through the center of the web) after the plumb wire was cut so that the heavy bobs would hang in a damping bucket filled with water and set on the floor of the level.

About 4 ft above the level two 2x4's were securely nailed, one on each side of W-1 and approximately horizontal. The plumbing device was set on these beams so that W-1 passed through approximately the center of the large hole and the device was secured to the beams and leveled using screws provided for that purpose.

The procedure was to steady W-1 and start observing its oscillations on Scales A and B through the two peep sights. With a man reading each scale and one timing and recording, simultaneous readings were taken of the wire position every 12 sec for 5 min. After at least 5 min wait the procedure was repeated and the averages of the two sets of readings had to check to closer than half a scale division; otherwise a third set of readings was taken. If consistent sets of readings are not obtained after three or four repetitions the wire must be examined throughout its length to see if any outside influence is responsible for the erratic results.

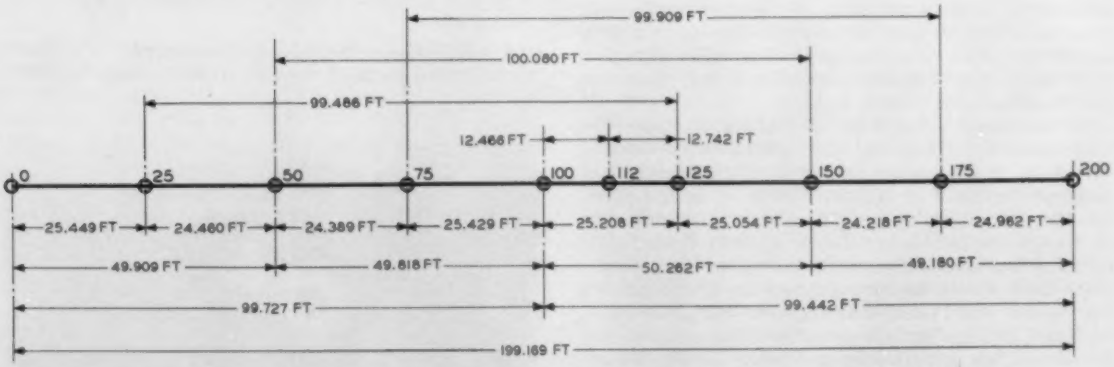
After it was felt that a satisfactory average reading had been obtained on each scale, plumbing wire was removed and a tarpaulin rigged above the plumbing instrument to deflect the water. The arm of the device was then moved over the hole in the device and the pointer accurately set at the observed mean position of the plumb wire as determined from the average of the scale readings. The pointer has a small center hole in its base so that a short plumb line may be suspended beneath it to facilitate surveying this point from either above or below the device. Once this point has been so transferred to the plumbing device it may then be very accurately transferred to a securely anchored spad above the device and/or a zinc strip beneath it and the device may then be removed.

The same general procedure was repeated for W-2 except that care was taken so that observations could also be made on the wire when hung from W-3 without readjusting the instrument. After determining the mean position for W-2 the plumb wire was then moved to the W-3 position and its mean position determined. The wire was then removed, temporary roofing built over the instrument, and the pointer set on the mean position of either wire. After all angular and linear measurements were made for one setting, the pointer was moved to the second position. Transferring these points to spads or zinc strips is not worthwhile as a rule and is merely an avoidable source of potential error.

Trying-in to Underground Control: Once the three points had been transferred underground two random set-ups, RSU-1 and RSU-2, shown in the diagram, were selected so that W-2 fell to one side of W-1 and W-3 fell to the other and so that the distance from each random set-up to the near wire was as short as possible (in practice about 6 ft). The angle at each random set-up between W-1 and each of the other wire positions did not exceed 15′ and was usually closer to 10′. Thus an effort was made to utilize the strongest possible Weisbach triangle as mathematically demonstrated by Briggs.

Permanent control stations were established under and/or over each random set-up and at each set-up the angles were turned from 1100A to each of the wire positions and to the other random set-up. All distances as shown by solid lines in the diagram were taped. In effect control was obtained by means of the solution of four Weisbach triangles and tied in to triangle RSU-1, RSU-2, 1100A. The average azimuth resulting from the four solutions appears to be accurate ±6″ as determined from Peters' formula for determining the approximate value of the probable error of the arithmetic mean.

Plumbing the Van Mater Shaft: Three points were transferred from the collar of the Van Mater shaft to the 1100 level the same way as at Ivanhoe. Control was taken off underground by setting up the transit directly beneath the W-1 wire position and the angles were turned from the W-2 and W-3 positions to permanent level control. The angle W2-W1-W3 as observed underground corresponded



Details of tape standardization range established in an inactive part of the mine. Nine spads were set at 25-ft intervals in back of drift and distances then determined with tape already checked by the U. S. Bureau of Standards.

to that angle as observed on the surface to 9". This method was used instead of the Ivanhoe system for several reasons. For one thing, the distance between W-1 and the other two curves was 22 ft in the Van Mater shaft and only 12 ft in the Ivanhoe shaft. Thus it was less difficult to obtain accurate results by the direct method at Austinville than would have been possible in the Ivanhoe shaft. Furthermore, due to the nature of the rock excavation around the station at the Van Mater shaft, the positioning of W-1 in order to use Weisbach triangles could only have been about 7 ft from W-2 and W-3. Such an arrangement would result in a relatively weak Weisbach triangle according to Briggs' analysis. Incidentally, this direct method was far simpler than that used at Ivanhoe in that it required fewer observations, calculations and adjustments.

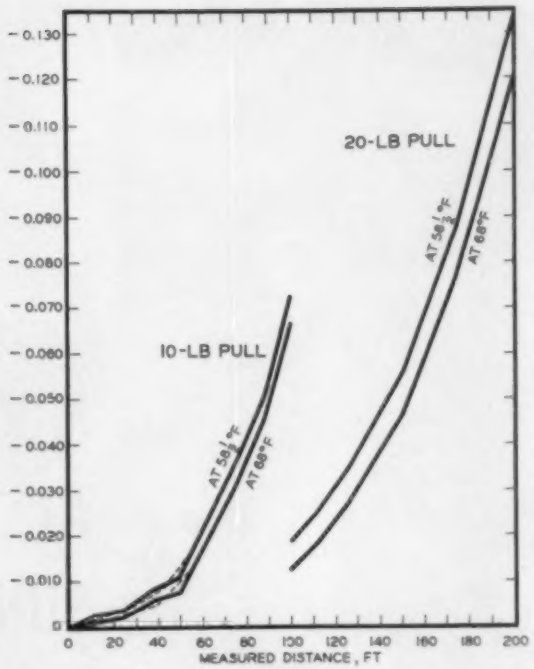
THE DEGREE OF PRECISION

It may appear to some that the degree of precision that was obtained in this project was considerably in excess of the requirements. This is true, but let it be stated that the cost of such excess precision should be considered as relatively cheap insurance that the tunnel junction would be accurately made. Actually the formulation of the surface control system and plumbing methods and the application of these elements of the engineering control net were carried out over a period of about three years so that much of it was done at times when the engineering staff was not overloaded with other tasks. Furthermore, once procedures were developed to obtain the desired minimum degree of precision, it was possible to obtain considerably more than minimum requirements with very little added time and care. For example, the use of the second random set-up in taking control off on the 1100 level at Ivanhoe was not essential, but since it could be done while observations were being taken from the first random set-up it only required one additional engineer and no extra time. It certainly contributed to the reliability of the results that were thus obtained.

Previous plumbing experience in the wet shafts at Austinville had made it clear that only by the use of an instrument such as the plumbing device described here could minimum standards be obtained. Once the device had been designed and fabricated, there was no sense in not using it to the limits of its capabilities.

Taping by hand held methods using a tension scale as recommended by the U. S. Coast & Geodetic Survey would ordinarily be required to assure minimum accuracy, but this necessitates a four- or five-man crew and requires a certain amount of skill to hold the tape steady enough for good readings. The use of taping stands with tension applied by means of a weight reduced the crew size to two men and permitted reading on an absolutely steady tape. Tape readings were repeated primarily in order to avoid blunders such as transposition of figures or unintentional reading to the wrong tape markings. Such a precaution reduced the probability that a traverse would not close accurately enough and would have to be re-run.

The procedures described above did result in an accurate tunnel closure. The triangulation net



Correction curves for one tape, No. F 1684, show typical data derived from use of tape standardization range. Nine stations were used in arriving at calibration curve.

checked out with an old 2150 ft base line at Ivanhoe to 0.029 ft, actually within the limits of accuracy of the original taping of this base line. Since the triangulation stations on the Van Mater and Ivanhoe headframes were mutually visible, the bearing of the line between them was checked by turning angles from each end and comparing with the calculated bearing based on the newly established coordinate system. The observed bearings corresponded with each other exactly and differed from the calculated bearing by 3".

As previously stated, the engineering control system was carried out for a period of three years. As a result, more than a dozen engineers and technicians participated in the project so that credit for the work rests generally with the Mines Engineering Dept. at Austinville.

The author wishes to express his appreciation to C. G. Morgenstern, superintendent of the Bertha Mineral Div. and to A. R. Flinn, eastern manager of mines, for their suggestions and help in the preparation of this article. He also thanks New Jersey Zinc Co. for permission to publish the article.

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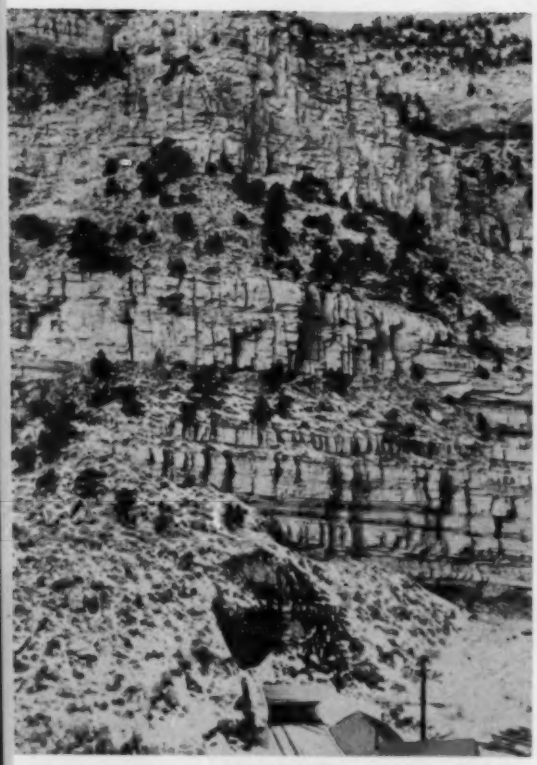
Discussion of this article sent (2 copies) to AIME before Oct. 31, 1958, will be published in MINING ENGINEERING.



Rock strata above coal seams. Note the massive sandstone beds above the portal.

by JOHN PEPERAKIS

MOUNTAIN BUMPS AT THE SUNNYSIDE MINES

Coal mine bumps are normally associated with pillar mining under moderate or deep cover. Severe bumps at Sunnyside, however, have not been confined to pillar lines. Many have occurred in virgin development and in localities a long way from active pillar workings. As early as 1918 bumps in virgin territory were attributed to the faulted structure in the Sunnyside area.[1]

Sunnyside is an old property, mined for more than 60 years. Both man-made and natural conditions contribute greatly to bump occurrences, and loss of life and great destruction of workings have resulted from some unusual bumps in recent years.

Before Kaiser Steel acquired the Sunnyside Mines in 1950, about 21 million tons of coal had been extracted. Large areas had been worked out and equally large areas first-mined. As demand for coking coal gradually diminished, extensive blocks were shut down, and during the low production period of the 1930's mining on a very limited scale was confined to a section of the property close to the coal tipple. Following purchase of the property Kaiser Steel developed the mines into a fully modernized operation.

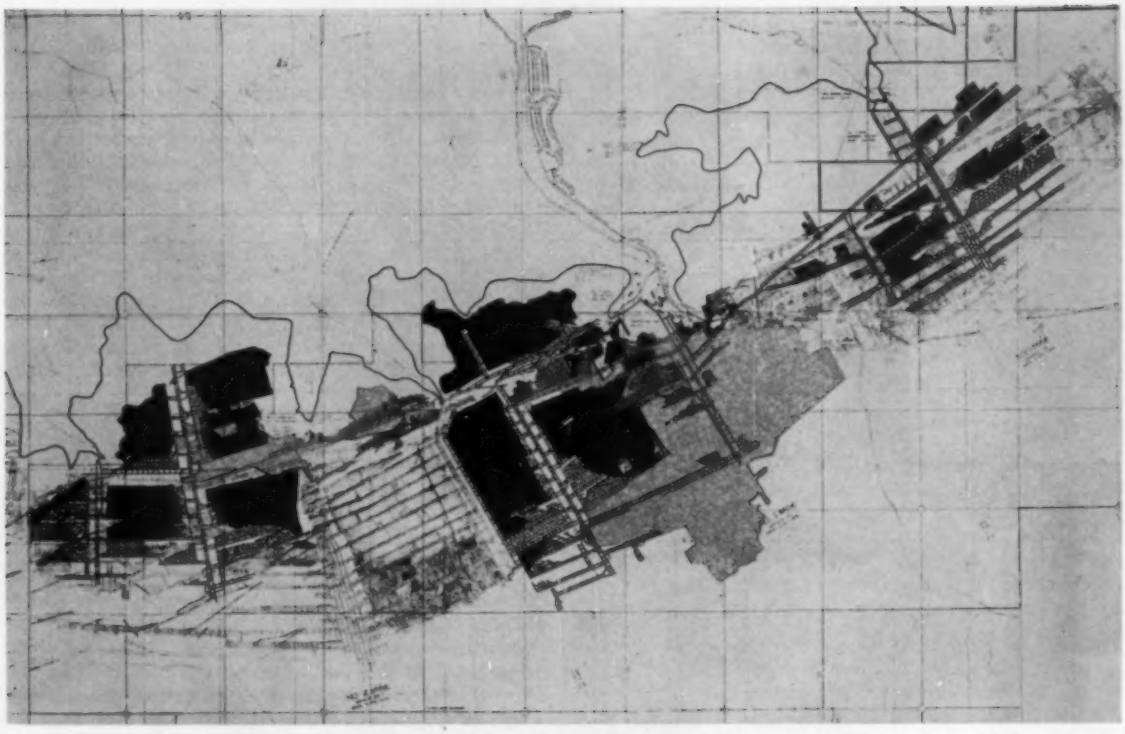
The worked out and first mined areas covered about four square miles extending five miles along the strike and up to one and a half miles down dip from the outcrop. The sections with favorable mining conditions and clean coal had been largely extracted under the selective mining system imposed by economic conditions and the lack of cleaning plant facilities.

Large reserves remained on the fringes of the worked out sections and in areas under deep cover and difficult roof. There were also considerable reserves in first-mined areas. In recent years much of Sunnyside's daily output of 7000 to 8000 tons has been derived from the partially mined localities. Many bumps have occurred when pillars have been pulled within the first-mined areas and on the fringes. The bumps have been associated with retreating pillar lines backing up against old workings and pillar lines in old first-mined areas backing up against highly stressed oversized barrier pillars surrounded by smaller pillars.

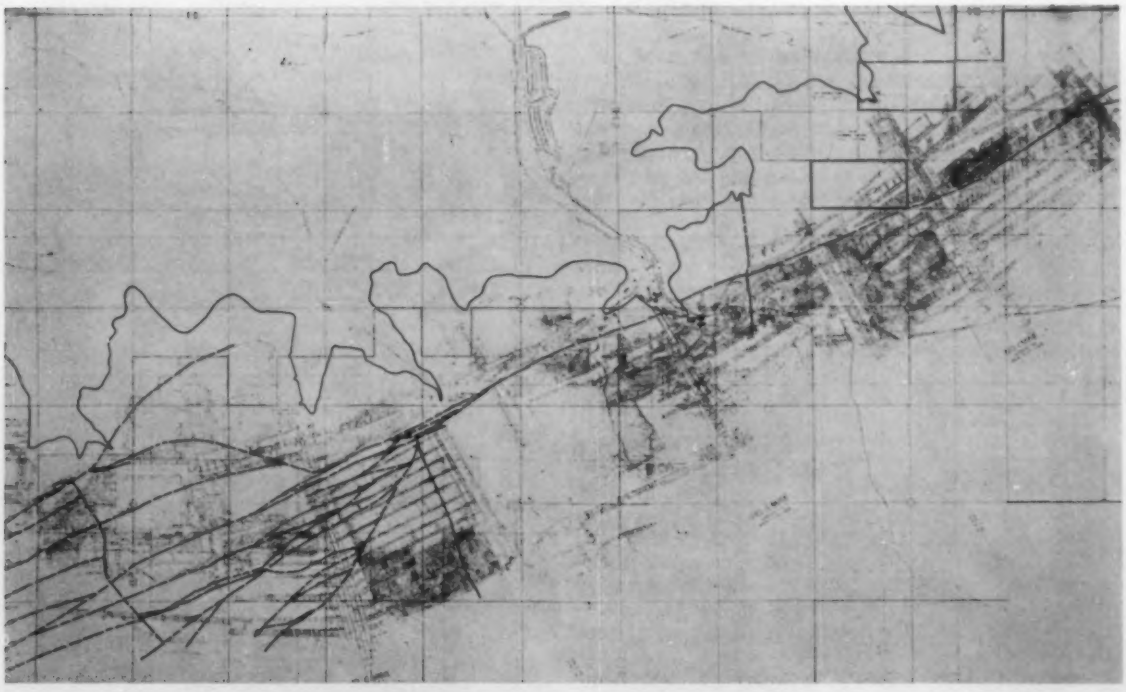
In some parts of the property the upper Sunnyside seam was extensively worked in the past, and sizable areas of old works overlie the present lower seam workings. Abutment pressures from barrier pillars and pillar remnants are transmitted to the lower seam, contributing to bumps and squeeze conditions.

Cover: The terrain is exceedingly rough, and cover varies considerably over relatively short horizontal distances. For example, at No. 1 mine the 2000-ft cover line is ony 2700 ft from the coal outcrop, and at No. 2 mine the cover over the main hoisting slope increases from 1000 to 2000 ft in a horizontal span of 1200 ft. Cover over the present mining sections ranges from several hundred feet in the valleys to 2500 ft under the crest of the divides. A short distance ahead of Sunnyside's deepest development down dip the cover reaches 3000 ft or more.

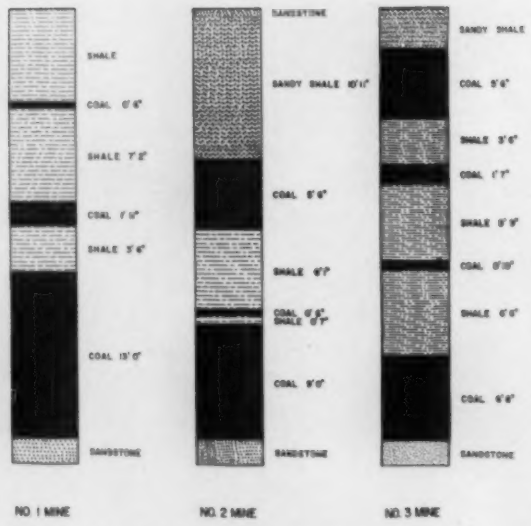
J. PEPERAKIS, Member AIME, is Manager, Sunnyside Coal Mines, Kaiser Steel Corp., Sunnyside, Utah. TP 4770F. Manuscript, April 21, 1958. New York Meeting, February 1958.



Sunnyside mines 1, 2, and 3. Solid areas, mined out lower seam; stippled, mined out upper seam.



Worked out and first mined areas covered 4 sq miles. The main Sunnyside fault zone.



Cross section in vicinity of Sunnyside seams.

Over the coal the cover is predominantly massive sandstone, some beds reaching a thickness of several hundred feet. One massive bed of sandstone 200 ft thick is 150 ft above the coal seam. Failure or loading of this sandstone or other massive beds above it by subsidence movements is bound to create widespread disturbances in active sections around the periphery of a worked out area.

Immediate Roof Over Seam: Although the overlying formation is predominantly sandstone, the immediate roof over the coal is generally very poor, being composed of shales, sandy shales, thin laminations of sandstone and shale, and rider seams. This roof condition does not cause bumps, but it seriously increases the effect when they occur. Major bumps are usually accompanied by roof falls, some very extensive, and extraordinary roof support measures are needed to protect men and property.

Floor of Seam: Underlying the coal seam is a strong massive sandstone bed 20 to 50 ft thick, separated from the coal by a thin shale ranging from a few inches to several feet. It is believed that this sandstone member contributes greatly to bump occurrences.

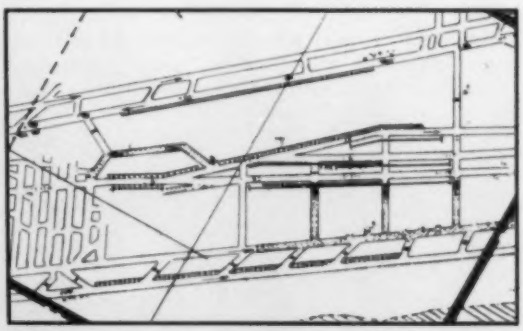
GEOLOGY AND FAULT STRUCTURE

The Lower and Upper Sunnyside seams are the only workable seams outcropping along the Book Cliffs, a prominent escarpment in southeastern Utah lying on the northeastern flank of the San Rafael Anticline and the southern flank of the Uinta Basin Syncline. The strata dips under the cliffs to the northeast at 3° to 11°, the steeper dip generally prevailing near the outcrop. Except for a few localities, all present mining is carried on in the Lower Sunnyside, which ranges from 5½ to 16 ft in thickness. Separation between the lower and upper seam varies from 1 to 45 ft. The upper seam attains a maximum thickness of 6 ft, and in the past it was mined extensively because of more favorable top conditions and cleaner coal. At present it is mined in conjunction with the lower seam in localities where the separation is thin enough to warrant handling in the coal washery. In some localities, particularly in No. 1 mine, the upper seam splits into a number of thin rider seams. The nearest split, 2 to 3 ft above the lower seam, results in an exceedingly difficult roof control problem.

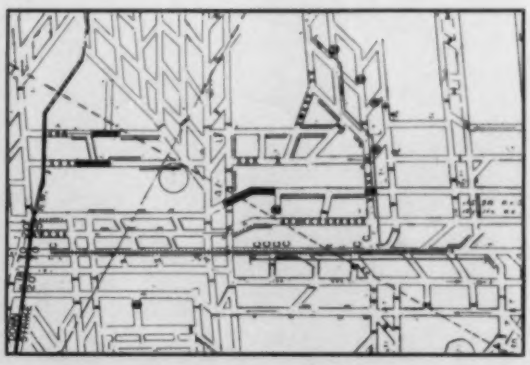
Faulting is very extensive. One prominent fault zone extends roughly along the strike through No. 1 and No. 3 mines, then swings down across the pitch and fans out into the No. 2 mine. Maximum displacement runs up to 33 ft; more commonly displacements range from 2 to 24 ft. There are also a few faults in the No. 2 and No. 3 mines running at right angles to the strike, one having a maximum displacement of 90 ft at the outcrop. The displacement diminishes toward the dip or away from the outcrop, so this type of fault does not pose undue problems in crossing with strike development. However, in one instance a dip fault contributed to the extraordinary caving of a slope.

Relation of Fault Structure to Bumps: It is not known whether tectonic movements due to the fault structure have some relation to the cause of bumps or whether the bumps cause movement along fault planes. The possibility that the unusual type of bump originates at the fault structure cannot be discounted, as the following instances will show:

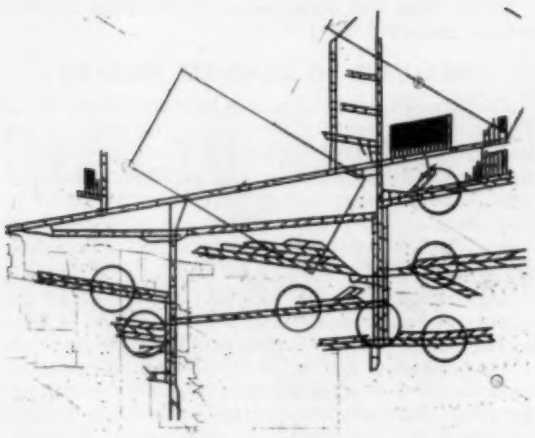
1) In 1918, during the driving of a slope in No. 2 mine, there was considerable trouble from bumps, which could not be explained by commonly accepted theories concerning occurrences in other parts of the mine and in other mines of the same district. Previously there had been heavy bumps in pillar workings under heavy cover, but in this instance the workings were in virgin territory 1500 ft from the nearest pillar operations. Trouble was first encountered soon after the slopes penetrated a fault having an 18-ft displacement. As the slopes were driven



Bump of Jan. 24, 1957.



Bump of Jan. 27, 1957.



Bumps experienced in virgin coal on development.

downward, the frequency and force of the bumps increased, and the operating company resorted to heavy concrete wall construction and heavy timbering and lagging to protect personnel. Despite the obstacles presented, the slopes were finally driven 840 ft, where a 17-ft fault was encountered. After the fault was crossed and the slopes continued to advance no further bump disturbances were noted.

2) In 1951 an 1800-ft tunnel, the main haulage entrance into No. 1 mine, was being driven through a rock formation to intersect the coal seam. As the tunnel face approached to within 30 ft of a dip fault the face became active and fragments of rock flew out when the face was disturbed by barring down and drilling operations. As soon as the tunnel penetrated the fault no further disturbance was noted. At the time, the nearest active pillar work was 4500 ft away.

3) At the Range Creek pumping station, some distance from the mines, a number of earth tremors have been noted. The nearest mine working is 15,000 ft from the station. The coal lies 3000 ft below surface at the pumping station and 3500 ft below the divide separating Range Creek from Sunnyside. Tremors have also been felt in the townsite several miles from the mines, sometimes without any known occurrence of mine bumps.

4) Following a very extensive occurrence Jan. 24, 1957, the rock strata immediately adjacent to the main Sunnyside fault plane was violently shattered.

5) On Dec. 13, 1957, a violent bump manifested itself along a distance of 7000 ft. It was simultaneously recorded by men working at four points along three different fault planes in No. 2 mine. The epicenter of the bump could not be determined.

6) Disturbances have been noted in the vicinity of the main fault zone along slopes and haulageways, the most recent occurring on Nov. 21, 1957, in No. 1 and No. 2 mines. On this date indications of movement were discernable at the inby end of the No. 1 mine rock tunnel where it intersected a block formed by a strike and a dip fault. Along the same fault zone 13,000 ft distant in No. 2 mine where the faults cross the main slopes, disturbance was noted in the form of rib sloughage immediately adjacent to the fault planes. In both localities cover is less than 500 ft.

7) Most of the really severe bumps that have struck the workings in recent years have taken place close to the main Sunnyside fault.

UNUSUAL BUMP OCCURRENCES

In addition to these occurrences, there have been extremely violent bumps near the intersection of the main slopes of No. 1 mine with the main Sunnyside fault. These slopes first penetrated the fault in the early 1940's, and since that time there have been four major bumps in the area:

December 1944 Occurrence: The mine was almost entirely on development at this time, and except for one 700x300-ft section the nearest pillar area was more than a mile away. This small pillared area was about 2000 ft from the center of the bump. The slope entries had been advanced some 1000 ft below the Sunnyside fault zone, and cover over the area was approximately 1500 ft at the time of the bump, which centered over the main slope about 400 ft below the fault. Immediately following this occurrence a 350-ft section of roof over the main slope started to work, caving in about 45 min. The other slopes in the area were badly shaken but did not cave.

November 1952 Occurrence: At 11:40 a.m. on November 11 there was a bump of such magnitude that it was felt through most of the mine and at least two points on the surface. The areas most intensely affected were the outby end of the new partings, the Motor Road Extension, and the outby end of the old Motor Road parting. Extensive rib sloughage occurred at all these locations, and many crossbars

Airway reinforced by cribs.

Yieldable arch support on main haulage slope.

were knocked out on the old Motor Road. Rib sloughage in one aircourse extended clear to the surface, and outcrop openings being driven at the time were shaken up.

January 1957 Occurrences: Starting January 24, a series of bumps caused great damage to the main slope area between the fault and the 7th Left. The first of these, at 5:50 p.m., was the most severe of the series. Damage to the main slopes was very extensive; a heavily bolted section of roof in the track slope settled on the bolts throughout 500 linear feet of the entry, and the 80-lb track on the same slope was heaved and thrown out of line for a distance of 1300 ft. A concrete sill, used as a base for timber, was also thrown out of alignment for a distance of 175 ft, and six concrete stoppings and one overcast were damaged. Caves resulting from these bumps were all in the left side slopes and amounted to a total of 550 linear feet of entry. There was roof breaking over the entire bump area, both in areas with a bolted rock roof and in entries where top coal had been left. In the vicinity of the 5th Left parting 2000 linear feet of top coal roof was shattered. This had to be dropped and the exposed rock bolted.

Another severe occurrence in this series was recorded on January 27, centering in the vicinity of the main parting. Like the bump above the fault in 1952, it was very general and not as centralized as those that have occurred below the fault. This bump induced one small cave and generally shook up the main parting area. The seismograph at the University of Utah 120 miles away recorded a local tremor at the exact time.

Both the January 24 and 27 occurrences were felt throughout the towns of Sunnyside and Dragerton.

December 1957 Occurrence: At 10:08 a.m. on December 4 one of the main slope pillars, between the manway and return above 4th Right, bumped with extreme violence and the entire left side of the pillar burst for a distance of 220 ft, filling the manway with rock.

This entry had caved previously, and the cave had been used as fill and graded over, with only a ventilation area left open in the rock strata overlying the coal. This bump, therefore, was a rock burst rather than a coal failure. Roof and ribs in this entry had been bolted in 1954 with 8-ft bolts on 2-ft centers or less.

The parallel main slope was also badly shaken and had it not been for extensive roof bolting, 12x12-in. crossbars, and cribs, there would have been considerable caving on the haulage slope and nearby aircourses.

The tremor from this bump was felt throughout Sunnyside townsite. The seismograph at the University of Utah again registered a local tremor at the exact time of the occurrence.

Bumps in Development Work: In the early 1940's during initial development of No. 1 mine there were many bumps in development headings in virgin coal. These were not of the type normally associated with popping of coal from the face, as is the case in most deep work; they were of such magnitude as to break the top, knock out timber support, and cause roof falls, some very extensive.

The same type of occurrence prevailed at No. 2 mine. Slope and entry headings in virgin development bumped violently, although the nearest pillar workings were 1500 to 2500 ft away.

Cover over the development work thus affected ranged from 700 to 2100 ft.

MEASURES TO MINIMIZE HAZARD

1) In any section subject to bounces, long holes of 2¾-in. diam, up to 20 ft long, are drilled into the face and into the side of pillars having a tendency to bump. A relatively small charge of explosives is used. Many violent bumps have been triggered by this means. The load-carrying capacity of large blocks or pillars has also been reduced by long-hole shooting.

Although this system has not worked in all instances, it has proved one of the best means of triggering bumps while the men are in a safe place; its use is continuing and will be expanded. If manufacturers were to perfect a good long-hole drilling and tamping method, this system would be greatly improved.

2) Large blocks have been cut into smaller, more uniform pillars ahead of the retreating pillar line. This is especially important in areas cut up by old works where large barrier pillars are surrounded by many small ones. Long-hole shooting is used in cutting up these blocks, which cause more trouble at Sunnyside than anything else encountered along a pillar-line point.

This method is certainly no cure-all, since in many cases these large blocks are already stressed and violent bumps may be triggered as they are being cut up. Also, cutting up blocks too far in advance of the pillar line may induce an uncontrollable squeeze on the area.

3) In developing room blocks it has been found wiser not to drive connecting rooms through the block from one entry to another. At Sunnyside there are always violent bumps when a retreating pillar line backs up near an old opening. It is far better to leave the block solid in development.

4) In sections where the top will stand, it has helped considerably to break up entry blocks into pillars of uniform size ahead of pillar mining, but where roof conditions are poor the block system has not worked very well.

5) Maximum roof support is stressed in all areas subject to bumps, regardless of the means used to reduce the severity. Roof bolts are widely used in combination with cribs, crossbars on cribs, and 16-in. diam props.

6) In slope areas and haulageways where the unusual type of bump is likely to occur, the steel yieldable arch type of support is used extensively to minimize roof falls following a bump. Roof bolting and wooden support has been found lacking in this respect.

7) In one locality Sunnyside has resorted to hydraulic backfilling in extensive areas of old workings to obtain some relief from the burden imposed by bumps.

It is unlikely that bumps can be eliminated completely in mines operating under deep cover, especially where they occur even in development openings, but the effects can be minimized by the practices enumerated and by the use of proper roof and rib support.

Reference

[1] A. C. Watts: An Unusual "Bounce" Condition. *Coal Age*, Dec. 5, 1918.

Discussion of this article sent (2 copies) to AIME before Oct. 31, 1958, will be published in MINING ENGINEERING.

by WILLIAM F. CAMPBELL

DEEP COAL MINING IN SPRINGHILL NO. 2 MINE

One of the deepest coal operations today is the Springhill No. 2 mine of Cumberland Railway & Coal Co., subsidiary of Dominion Coal Co. Ltd. Mining is now conducted at a slope distance of 14,000 ft, with 4400 vertical ft of cover. The record of Springhill No. 2 can be said to contain the history of bumps in the Province of Nova Scotia.

The Springhill coal field forms part of the Cumberland field of Carboniferous age. There are seven mineable fields in the area, numbered in the order they were discovered. Mining has been carried on in all but the No. 4 and 5 seams, but present operations are confined to the No. 2. Fig. 1 shows a vertical section through the seams.

Opened in 1873, No. 2 mine was first worked from parallel slopes driven from the outcrop of No. 2 seam down to the 7700 level. As the mine went deeper, a two-place auxiliary slope was driven from the 6900 level to the present workings. A transfer level at the 7800 connects the main haulage with the auxiliary haulage slope. The No. 2 mine plan is shown in Figs. 2 and 3.

The seam is bituminous, averaging 8.5 to 9 ft thick. There is a well defined parting 14 to 16 in. from the roof, and this roof coal is harder than the rest of the seam.

Average pitch at the outcrop is 30°; at the 6500 level, 20°; at the 7900 level, 16°; and at the 13,800 level, 10°.

Immediate roof and floor strata consist of beds of variable thicknesses of shales, grading to arenaceous shales to shaly sandstones to sandstones. A characteristic of the strata is the appearance and disappearance of sandstone bands, of considerable thickness, over distances of several hundred feet.

MINE HISTORY

Entrance to No. 2 mine is obtained by three parallel slopes, separated by 100-ft pillars except in the upper portion of the mine where the pillars are smaller. Main haulage levels were originally driven 600 ft apart for room and pillar extraction. A parallel drainage and intake airway was driven below each haulage level and a parallel return airway (counter level) above. Pillars 80 to 100 ft wide separated these two servicing entries from the center haulage level. Inclines up to 700 ft apart were driven off the levels up pitch to the upper levels, and at 40-ft centers level rooms 12 ft wide were driven off each side of the inclines, separated by crosscuts every 50 to 100 ft. The rooms were driven up to 350 ft or until they were *holed* into the room from the adjoining incline—a plan followed until the level reached its boundary. When the entire area between two levels had been divided into pillars, the pillars were extracted from the boundary back to the slope pillars.

As depth of cover increased, mining conditions required larger pillars, and at the 3300 level, where

NECESSARY PRECAUTIONS FOR MINING AT DEPTH

In Room and Pillar Extraction:

1) Pillars must not be too small.

2) Pillar size must be uniform.

3) Extraction lines must be kept as straight and as uniform as possible. If they are irregular they should be brought back into line slowly.

4) Peninsulas of coal surrounded by gob must be avoided.

5) Pillars should not be disturbed after they have been formed. If it is necessary to increase the width of an opening, stripping or ribbing should be done gradually over a long distance. If increased width of openings is necessary at certain locations and can be anticipated, the openings should be widened during development.

6) Under no conditions should small pillars be left in the gob that would interfere with caving.

In Longwall Operations:

1) Pillars formed during development for retreating longwalls should be uniform in size and shape.

2) Pillars should not be split after development, but if pillar splitting does become necessary it should not be carried out within the zone influenced by the working faces.

3) Width of levels should not be increased after the levels have been developed. If it does become necessary to widen a level it must be done gradually over a long distance by stripping or ribbing the coal ribs.

4) Extraction lines should remain uniform. If several walls are worked together—one behind the other—a uniform distance must be maintained between them and the wall faces must be kept as straight as possible. If the walls do get out of line, they must be brought back into line gradually to allow for a gradual change in the stress distribution over the area.

5) Stumps of coal, roof supports, etc. must not be allowed to remain in the gob to interfere with caving.

6) Midwalls should be built as rigidly as possible and properly maintained.

W. F. CAMPBELL is Resident Superintendent, Cumberland Railway & Coal Co., Springhill, Nova Scotia. TP 4774F. Manuscript, April 21, 1958. New York Meeting, February 1958.

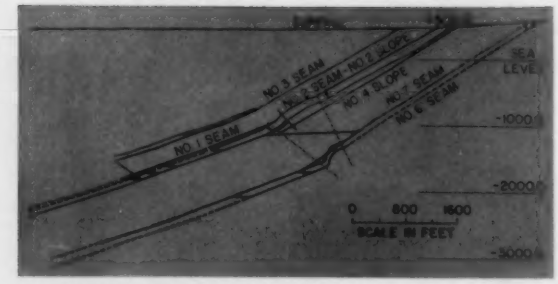


Fig. 1—*Vertical section through No. 2 slope.*

Fig. 2—*Photograph of No. 2 mine plan.*

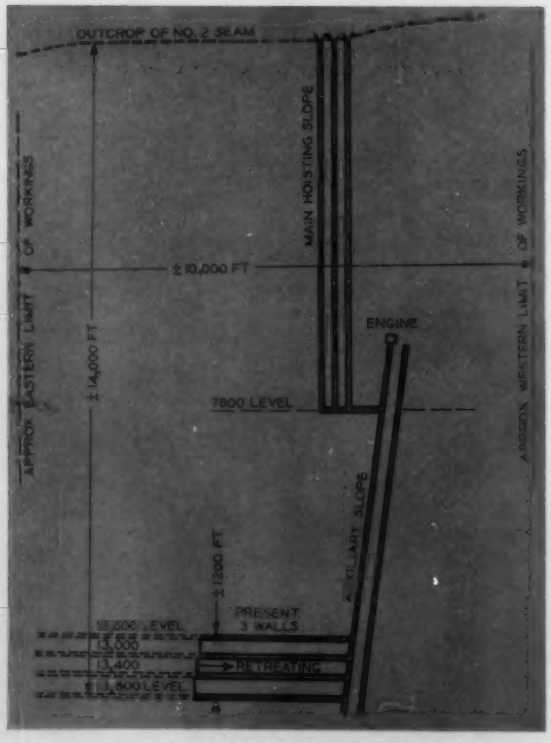


Fig. 3—*Simplified No. 2 mine.*

cover was 1600 ft, room pillars were driven on 50-ft centers and width of rooms and crosscuts was decreased from 12 to 10 ft. Even with these changes, excessive pavement heaving and roof falls required the additional work of cleaning up, and in many cases new rooms had to be driven on the high side of the old ones before the pillars could be extracted. When operations had to be suspended for a time, the entire section off the 3300 level had to be re-divided.

Change in Method: This led to a change in working method. On the 4000 levels, at 1800 ft of cover, rooms were not broken off the inclines until the levels had reached their boundaries. Room pillars were increased to 60x90 ft. This change did not correct the pavement heaving. In many cases when pillar extraction was started immediately after the room reached its limit, ribbing was necessary before the pillar was completely extracted.

After much consideration another change in method was adopted (see Fig. 4). The three-level entry system was maintained, and the levels were driven to their boundaries with inclines approximately 500 ft apart. When the level reached its boundary three rooms were driven from each side of the inside incline, and when pillar extraction began, rooms on the adjoining incline were started until three inclines were in operation. Pillars were 35 ft wide, the face of the advancing room was kept at least 40 ft ahead of the one below, and each pillar was brought back 40 to 50 ft ahead of the pillar below. Not more than three inclines and three rooms off each side of an incline were to be in operation at any one time. When the upper room pillar was brought back to the incline a new room was started off each side. The procedure was repeated until the level was reached and the area between levels was extracted to the slope pillars. This method proved satisfactory for the 4700 levels.

Early Occurrence of Bumps: The first recorded bump (Fig. 5) occurred July 1917 at the No. 3 incline, 4700 level, accompanied by a heavy fall of roof stone. Damage was confined to the empty turnout, where the high road was heaved and broken for 150 ft. Shortly before the bump occurred the high side coal had been ribbed 10 to 12 ft to allow for a spare road. Subsequently several other high side bumps occurred on this level at locations where it had been widened for spare roads.

Several coal bumps were experienced in rooms off the inclines of the 4700 West level, usually in those being driven toward the gob and in their last 50 ft or so of driving. After the room reached its boundary there were no further stress troubles during pillar extraction.

On the 5400 West level there were a great many bumps at the turnout or spare road locations, where the high side coal had been stripped for 10 to 12 ft. Many coal bursts and bumps occurred in rooms that were being driven, especially in those being driven to the waste, and on several occasions pillar bursts completely closed them with coal. These bumps occurred off inclines 2, 3, and 4 and were severe when the rooms got out of line. When the extraction line was maintained as shown in Fig. 4 the room bumps were not as serious.

The 5400 East level, under 2200-ft cover, was not seriously affected until the district bump of Dec. 6, 1924, at 11:40 a.m. The position of the workings and extent of damage are shown in Fig. 6. There was a

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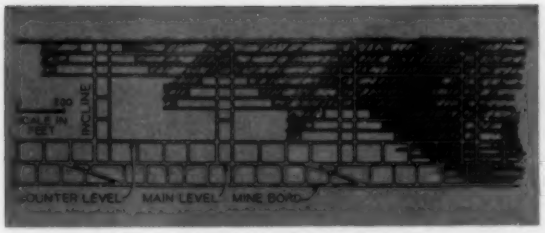

Fig. 4—*Room and pillar extraction adopted in an early attempt to lessen the danger of occurrence of bump.*

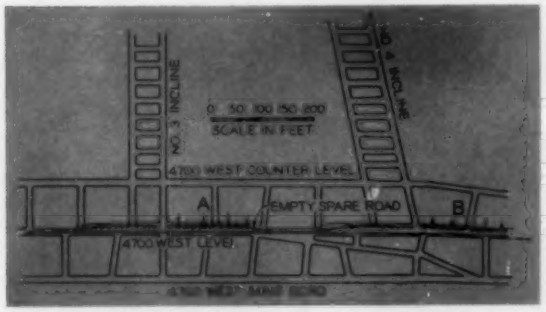

Fig. 5—*Bump of July 1917 on 4700 West level.*

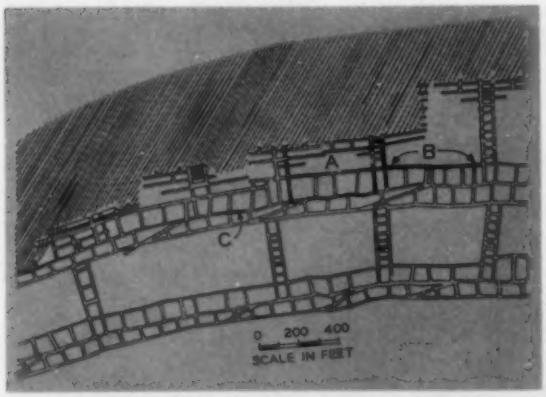

Fig 6—*This bump occurred on Dec. 6, 1924, at 11:40 a.m. The areas affected are shown cross-hatched.*

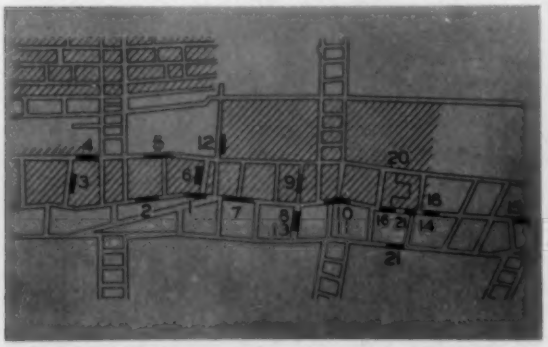

Fig. 7—*Plan showing bump locations during 5400 East longwall operations. Bumps numbered in order.*

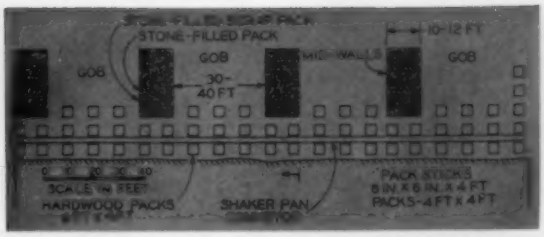

Fig. 8—*System of room support on longwall faces.*

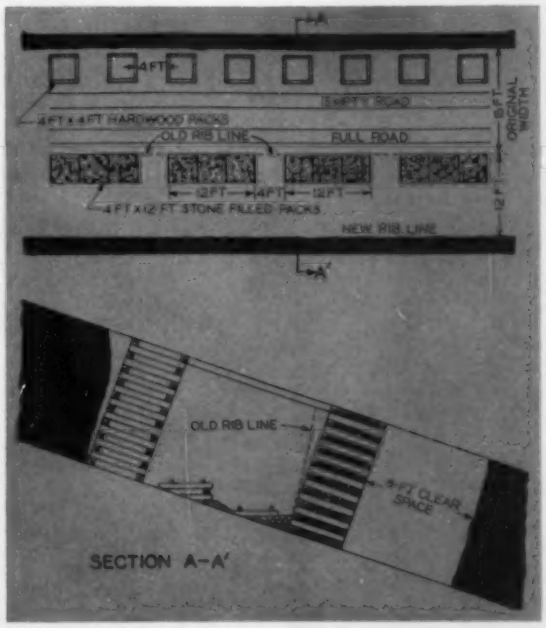

Fig. 9—*Plan showing widened levels.*

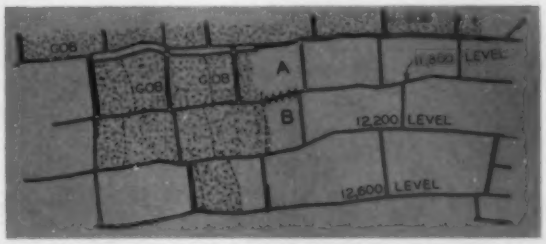

Fig. 10—*Position of faces and location of bumps on March 3 and 4, 1949. A) Bump March 3, 1949, completely filled this incline. B) Level bump March 4.*

Fig. 12—*Position of walls and extent of damage caused by bumps of November 22 and December 8, 1954. A) thrust from high side. B) thrust from low side.*

second bump at 3:30 p.m. The morning bump completely closed the level between No. 3 and 4 inclines; the rails were thrown up against the roof by the ejected coal and pavement strata. No. 4 incline was partially closed from the level to the counter level, and the pavement was thrown up to the roof at the center of the incline with enough space for a man to crawl up either rib. The remainder of the incline was badly damaged. No. 3 incline was closed up to the counter level, and from here on it was blocked by heavy falls of stone. The bump at 3:30 p.m. caused a fall outby No. 5 incline.

On the 5400 East level there were two bumps prior to Dec. 6, 1924. These occurred as rooms were being driven toward the waste off No. 4 incline.

At the time of the district bump, coal was being mined off five inclines. The extraction line was irregular; in fact, it could be described as a stepped extraction line, the extraction faces off No. 3, 4, and 5 inclines forming a wide second step and the steps running parallel to the strike of the seam.

It was apparent to mine officials that the critical depth of cover for room and pillar extraction in No. 2 mine was being approached. Very little was known about other methods of extraction, but after much discussion with government consultants and prominent engineers, a system of longwall mining was introduced. Working out a longwall system that would reduce bump occurrence was a major operation, complicated by the fact that the 4700 and 6500 levels had already been developed for room and pillar extraction. During the changeover to a satisfactory system, production dropped from 1900 to 600 tpd.

The No. 6 to 8 inclines, 5700 West level, were started by the room and pillar method, but mining was abandoned because of pavement heaving and several severe bumps.

Longwall Operations Begun: The first form of retreating longwall mining began January 1925 on the 5900 West level when the 90-ft counter pillar was started from No. 6½ incline. This short wall was lengthened at the No. 6 incline up to the 5700 halfway level, and the 5700 West wall was started at No. 6 incline. Several bumps were encountered, and a break in the roof strata allowed 200 gpm of water to flow from the abandoned No. 3 mine. In December 1926 the area was vacated because of the danger that the volume would increase if there were more bumps in this section.

Similar longwall operations were started on the 5400 East and West levels in September 1925. At first only the counter pillars were extracted, but when halfway level openings had been driven between the 4700 and 5400 levels, the walls were extended to these halfway levels.

Many bumps occurred in the 5400 East and West longwall areas, especially on the levels. These sections of the mine had been cut into small pillars for room and pillar extraction, and to afford greater protection against bumps, a coal area to the high side and inby these longwalls was left unmined. Fig. 7 shows the area mined by the 5400 East longwall and the location of the bumps recorded during this mining. Most level bumps occurred shortly after the level was widened and cleaned up for spare roads.

Roof Support: The longwall roof support finally adopted is shown in Fig. 8. Not more than three lines of packs are on the walls at the end of the loading cycle; the third line is drawn and the conveyor pans advanced during the maintenance shift. Coal is mined on two shifts with hand picks and chipper picks driven by compressed air—the third shift is for maintenance. At first no midwalls were built, but it was noted that if the roof stood 20 to 30 ft in the gob and then caved the face was severely damaged. To eliminate these face bumps continuous rigid lines of stone walls, 10 to 12 ft wide, were built on 40 to 50-ft centers, extending into the gob and allowing the roof to break between them. The midwalls proved very successful.

The 5900 and 6500 East levels had been developed for room and pillar extraction, and before retreating longwall mining could be introduced in this area, halfway levels (the 5700 and 6300) had to be driven.

In August 1926, when the 5900 level room and pillar workings had reached No. 8 incline, the 5700 and 5900 East longwalls were started. There were a number of difficulties, and many face bumps were caused by the small pillars that had been developed on the 5900 level for room and pillar extraction. Several level bumps caused considerable damage, and on July 3, 1928, a district bump claimed one life and injured two men. The 5700 East level outby No. 3 incline was severely damaged for 190 ft, and the force ejected coal and pavement from the low side of the level. This bump was distinctly felt on surface.

Most Dangerous Locations: Review of the bumps showed that those at the face were not severe and that the most dangerous zone was on the levels for a distance of several hundred feet from the face. To afford greater protection in this zone it was decided to strip the low side rib to provide an extra width of 12 ft and build substantial stone-filled packs in this space (see Fig. 9). An 8-ft clear space was left between the coal rib and the low side of the packs. It was believed that the clear space would provide a void for any low side coal or strata that would be disturbed during a bump, giving men working in the level a chance to escape. This widening of the level was to extend some 800 ft ahead of the retreating wall faces.

The 5700 East level had been widened in this manner (from 100 ft outby No. 3 incline to No. 1 incline) and also the 5900 East level (from the wall face to 200 ft outby No. 2 incline) when a severe district bump occurred, on Oct. 12, 1928, injuring four men. The wall faces were just inby the No. 3 incline. The 5700 level was damaged for 1350 ft starting 150 ft outby No. 3 incline. Portions of the 5900 level were damaged and coal was thrown from the high sides of the 6300 and 6500 East levels. One minor bump occurred on the 5700 level and three on the 5900 level during the time they were being widened.

Effect of Widening Levels: Although it was not recognized at the time, in the writer's opinion widening the levels had an important bearing on bumps that followed in this area. Drilling in the roof and pavement strata disclosed a 60-ft sandstone bed in the near roof. The irregular-shaped pillars, the severe bump, and the discovery of sandstone in the near roof led to abandonment of this district after the roadways were cleaned up.

Frequency of Bumps Increased: In October 1928 the 6300 and 6500 East longwalls were started. The 6500 East level had been developed for room and pillar extraction, with the three levels driven inby No. 8 incline. After the walls retreated past No. 8 incline the rate of bumping increased. This area contained pillars 80 to 200 ft wide. A great number of

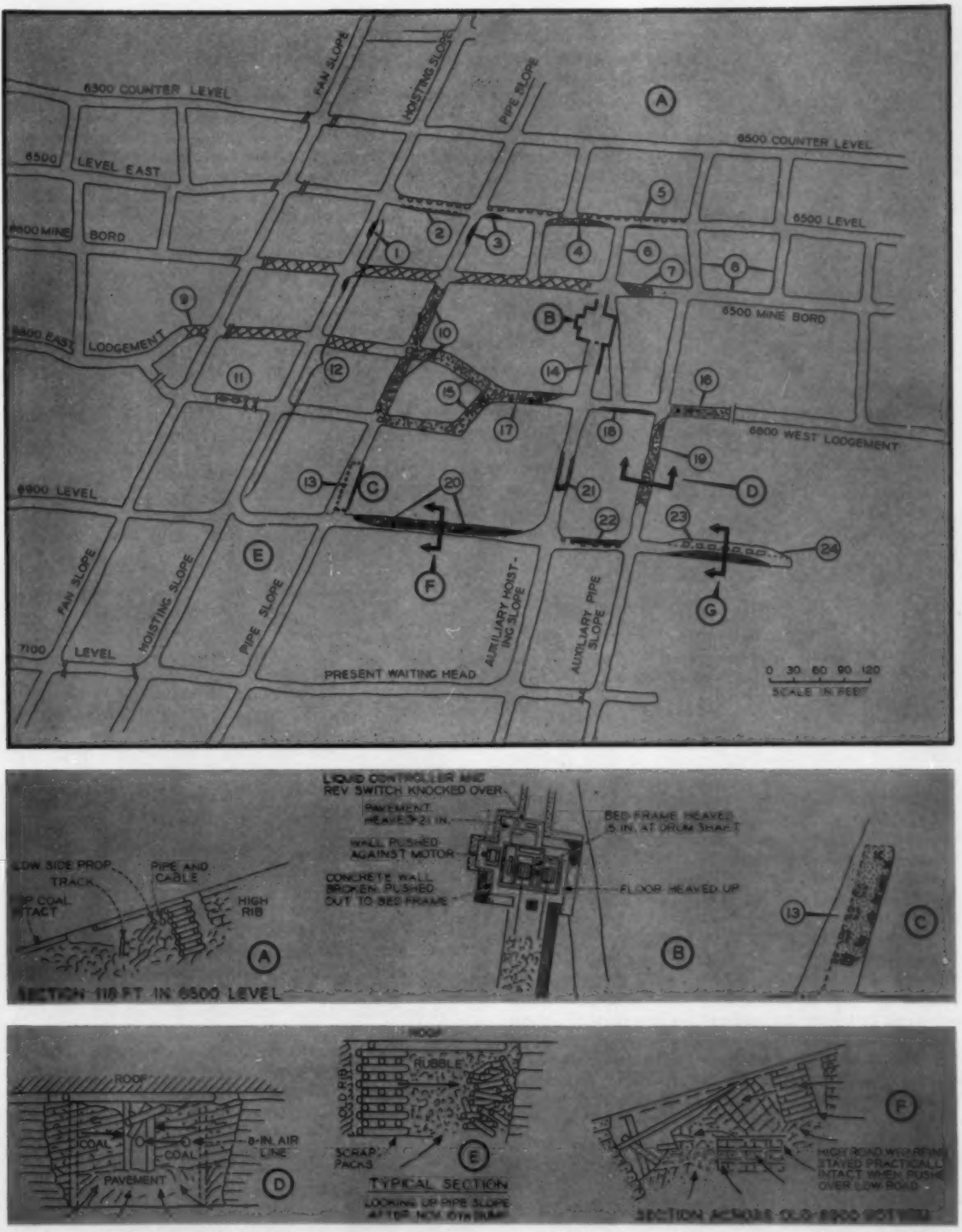

Fig. 11—District bump of Nov. 6, 1952—*1) Six west side props, rib kicked out. 2) Loose coal off low rib. 3) Eight west side props, rib kicked out. 4) Rib, props pushed to pack line; track coped to high side. 5) Broken water line, damaged low rib. 6) Ribs shaken, three I-beams down. 7) Ribs, packs pushed downhill; closed in. 8) Probably closed in. 9) Closed in by June 8 bump. 10) Pipe slope closed, some line breaks. 11) Airlock doors warped. 12) 300-ft track heave; line breaks. 13) Packs pushed to west rib; mine car smashed. 14) Pavement heaved; east rib kicked out. 15) Air, column line routes kicked in. 16) Packs pushed down, rib up; closed in. 17) High rib, packs kicked to low side; closed in. 18) Low rib coal knocked off. 19) West, east rib props pushed to east rib; closed in. 20) High rib kicked down, wharfing out, pavement heaved, track coped. 21) Pavement heaved, but ribs unaffected. 22) High rib, packs kicked downhill. 23) Low side props and coal kicked uphill; pavement heaved. 24) Drive for new lodgement.*

bumps occurred from No. 1 incline and inby for 1200 ft. Boreholes indicated that there were massive sandstone beds in the near roof, thickening in a westerly direction. Under these circumstances the area was abandoned 800 ft inby No. 1 incline in March 1932.

The 6900 and 7100 East levels were driven for longwall extraction. A very successful operation was carried out, and when the walls retreated to within 1700 ft of the main slope they were stopped because of the increased danger of bumps from heavy sandstone in the roof strata.

The 7400 and all subsequent east side levels were developed for retreating longwalls, and relatively successful operations were carried out on the east side of No. 2 mine. Level loaders were installed on the 9800 East, whereas previously coal had been loaded directly from conveyor pans into mine cars. The level loader consisted of a chain conveyor up to 300 ft long which carried the coal on the level from the face to a mine car loader. This installation lowered the height of level required at the face for mine car loading, reducing the amount of brushing done on the levels.

Effect of Small Pillars: In the 1930's, for experimental purposes, the 8600, 9000, 9400, and 9800 West levels were driven off the auxiliary slope. Inclines were driven off the 9000 and 9400 West levels at 100-ft intervals, and four rooms were driven off one of the inside inclines of the 9000 West level. A severe bump followed the driving of these rooms and two pillars burst outwards, completely demolishing three rooms. The roof was not affected. As the pillars between rooms proved to be too small, this district was abandoned.

Beginning in 1925, the main slope and its subsidiary roadways were affected by bumps. These were attributed to the small pillar size and to the fact that the coal pillars were disturbed during necessary re-timbering and pavement brushing. When operations in the overlying No. 1 seam became extensive the frequency of bumps on the main slopes increased, affecting these main entrances between the 3300 and the 6900 levels. Because of this increased bump activity, operations in No. 1 seam were stopped in 1954, and a decrease in the frequency of bumps on the main slopes followed.

A successful operation, relatively free from bumps in the extraction areas, was achieved from the 6900 East level, but on March 3, 1949, a severe bump occurred in faulty ground on No. 5A incline off the 11,000 East level, 300 ft from the wall face (see Fig. 10). This new incline was being driven outby a fault and had progressed 290 ft at the time of the bump, which threw the pavement up against the roof for the entire length of the incline. Twenty-four hours later a high side bump occurred on the level, damaging the level from the incline and inby 150 ft. The 10,600 East wall was 100 ft in advance of the 11,000 wall at this time.

At the time of this bump:

1) A pillar was in the process of being split.
2) No. 5A incline was being driven too close to the longwall faces.
3) The 11,000 East level had been widened at No. 5A incline.
4) The 10,600 East level had been widened inby the top of No. 5 incline, 11,000 East level.

As a result of this experience of one bump following another within 24 hr, an order was issued that no clean-up work was to be attempted for at least 24 hr following a bump.

In June and November, 1952, there was a series of bumps in the mine section between the 6500 and 6900 ft levels. The bumps in June were confined to the main slope and eastward from the 6500 to 7100 ft levels. On June 8 the 6800 East lodgement was badly damaged, and on November 6 a district bump occurred (see Fig. 11). The damage was extensive. Coal pillars burst outwards and coal and pavement strata were hurled into the openings. The nearest working places were in the 6900 West level, which was being driven for a lodgement, and the pipe slope was being ribbed above the 6900 level. While the 6900 West level was being driven it had previously bumped from the high side outby the auxiliary pipe slope, and on November 6 the low side bumped at the same location. The face was not affected by the low side bump. The pipe slope ribbing was not affected by the district bump on November 6, but this ribbing area bumped on November 8, and one miner was killed at the face.

This section of the mine had been split into small pillars of various shapes and sizes. These pillars were highly stressed. The driving of the 6900 West logdement, the ribbing on the pipe slope, or even the re-timbering and pavement brushing operations that had to be carried out could have triggered this district bump.

In 1954 two severe bumps occurred on the 11,800 level under 3800 ft of cover. On November 22 a high side bump completely destroyed the level from No. 4 incline to the face. The level was cleaned up. On December 8, a low side bump caused further severe damage to the level from No. 4 incline to the wall face. The position of the wall faces and the location of these bumps are shown in Fig. 12.

During the clean-up work after the first bump the 12,200 and 12,600 walls continued in operation. On November 22 the top of the 12,200 wall lagged far behind the bottom. On December 8, only a few feet separated the two walls and the top of the 12,200 wall no longer lagged behind the bottom.

To facilitate mining operations the 11,800 level was widened to allow a pack to be built between the track and the level chain conveyor. This level widening could have had a bearing on the high side bump. The relatively fast rate of change in the direction of the 12,200 wall face could have had an important bearing on the low side bump.

Three retreating longwalls—the 13,000, 13,400, and 13,800 walls—are in operation today.

To date some 500 bumps have been recorded in No. 2 mine. Many miners have been injured, and too often lives have been lost. It has been fortunate that in most cases bumps have occurred when men were absent from the affected areas.

It is strongly recommended that any precautionary measures against bumps be carried out solely by members of the mining engineering departments, for in the battle of winning coal at depth, underground officials are apt to be more concerned with daily, weekly, and monthly outputs.

The writer acknowledges indebtedness to H. Zorychta, mining engineer, Fuels Division, Mines Branch, Department of Mines and Technical Surveys, for assistance in preparing this article.

Discussion of this article sent (2 copies) to AIME before Oct. 31, 1958, will be published in MINING ENGINEERING.

by H. E. MAUCK

COAL MINE BUMPS CAN BE ELIMINATED

The many factors that control bumping must be carefully studied for each coal seam where bumps occur, and specifications known to exclude bumping should be incorporated in the mining plans. This calls for complete knowledge of the seam's characteristics and its adjacent strata, and in many instances these characteristics are not revealed until the seam is actually mined.

Pressure and shock bumps, the two general types, occur jointly and separately. In this discussion no differentiation will be made. Whether pressure or shock, they are treated as bumps, and both must be eliminated.

Bumps in mines have occurred in several places throughout the coal fields of the world. A study of many of these occurrences indicates that geologic characteristics, development planning, and mining procedure have contributed. But more specifically, there are conditions usually associated with bumps: thickness of cover, strong strata directly on or above the seam, a tough floor or bottom not subject to heaving, mountainous terrain, stressed and steeply pitching beds, and the proximity of faults and other geologic structures.

Mine planning should incorporate these known factors (not necessarily in order of importance):

1) Main panel entries should be limited to those absolutely necessary to ventilate and serve the mine. This reduces the span over which stresses may be set up that will later throw excessive pressures on barrier and chain pillars when they are being removed.

2) Barrier pillars should be as wide as practicable so that they will be strong enough to carry the loads thrown on them when final mining is being carried out.

3) Pillars should never be fully recovered on both sides of a main entry development if the barrier and chain pillars are to be removed later. The excessive pressures placed on the main chain and pillar barriers by arching of the gob areas can result in bumping when these barriers are being removed.

4) Full seam extraction is better accomplished by driving to the mine boundary and then retreat-drawing all pillars. If there are natural boundaries in the mine—such as faults, want areas, and valleys—retreat should be started there.

5) Pillars should be uniform in size and shape. The entire development of the mine should call for uniform blocks with entries driven parallel and perpendicular. Only angle break-throughs should be driven when necessary for haulage, etc.

6) For better distribution of rock stresses and reduction of carrying loads per unit area, both chain and barrier pillars should be developed with the maximum dimensions.

7) Pillars should be open-ended when recovered. If they are oblong, the short side should be mined first. Both sides of a block should not be mined simultaneously, but under no circumstance should the *lifts* be cut together.

8) Pillar *sprags* should not be left in mining. If they are not recoverable, they should be rendered incapable of carrying loads.

9) Pillar lines should be as short as practicable. (Three or four blocks are adequate). Experience has shown that rooms should be driven up and retreated immediately. The longer a room stands, the more unfavorable the mining conditions. This contributes to bumping.

10) Pillars should not be split in abutment zones (high stress areas lying close to mined out areas) and if slabbing is necessary, it should be open-ended.

11) Pillars should be recovered in a straight line. Irregular pillar lines will allow excessive pressures thrown on the jutting points. Experience has shown that the lead end of the pillar line can be slightly in advance.

12) Pillar lines should be extracted as rapidly as possible. This appears to lessen pressures on the line and render abutment zones less hazardous.

13) Extraction planning should call for large, continuous robbed out areas. Robbing out an area too narrow to get a major fall of the strata above the seam tends to throw excessive pressures on a pillar line.

14) Timbering in pillar areas should be adequate but not excessive. Too heavy timbering or cribbing is likely to retard roof falls and throw excessive weight on the pillar line.

15) Experience has shown that when pillar lines have retreated 800 to 1000 ft from the solid, bumps can occur. Because this distance may vary in different seams, impact stresses should be studied for each individual condition. In any event, extra precautions should be taken against bumps in this area.

This list of controlling factors may or may not be complete. It probably is not, but it covers most of the problem's significant aspects. The question is whether or not bumping can be eliminated. The answer is that bumping can be minimized and possibly eliminated if these and other established factors are thoughtfully considered and incorporated in the mining and extraction plans. If a mine has already been developed or the pattern set so that little change can be made, then it will be necessary to adjust to the most nearly practicable system that can incorporate the known factors.

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Discussion of this article sent (2 copies) to AIME before Oct. 31, 1958, will be published in MINING ENGINEERING.

CAUSE AND OCCURRENCE OF COAL MINE BUMPS

by CHARLES T. HOLLAND

This discussion is concerned with those comparatively infrequent bumps that eject material from the failed mass with enough energy to wreck heavy machinery and seriously injure or kill people. In such cases there is a loud report, and the pressure waves set up in the mine atmosphere wreck ventilation controls several hundred feet from the site of the failure. Vibrations are induced in the earth's crust which may be detected several miles from the point of origin, and explosive gases may be released in large quantities.* Usually a dense suspension of dust is produced from the failed mass, together with dust placed in suspension by the resulting air blast.

These rock bursts or bumps have also been called *mountain shots, bounces, pillar bursts,* and *crumps.* Such occurrences, when extensive, are serious catastrophes, and may force abandonment of the mine.[1]

CAUSES OF ROCK BURSTS

Rock bursts in coal mines have occurred in several places under diverse geological conditions, mining methods, and/or practices. A study of many such occurrences indicates that they depend on the following conditions: 1) cover thickness of 500 ft or more, 2) cover composed of strong members and having a strong member lying close to or on the coal bed, and 3) a floor that does not readily heave.

The minimum thickness of cover under which coal mine rock bursts occur is based on observation. Under unusual circumstances involving very strong roof members and/or mining systems, and/or practices especially likely to induce bursts, a burst conceivably could occur under less roof. Under special circumstances rock bursts have occurred in marble quarries almost at the surface.[2] Furthermore, under very heavy cover it is likely that controlling roof members need not be as strong and as close to the coal bed to cause bumps.

Just what constitutes a strong roof or roof member is open to question. Obviously the strength of a roof member is determined by its thickness, the distance between bedding planes across which little or no bond exists, the spacing and development of joints, and the inherent strength of the rock material. Strata sections showing roofs under which rock bursts in coal mines have developed are illustrated in Fig. 2. In several instances the strength of rocks composing the roof of mines developing bumps has been tested. The tests (Table I) show that these rocks develop considerable strength in compression, bending, and shear and that in some cases the strengths are very high. No quantitative data are available concerning joints in roof members over coal beds where rock bursts have occurred, but the author has examined many mines subject to bursts and has received the impression that joints in the shales immediately over the coal beds are always present and well developed. In the main sandstone or conglomerate members themselves, however, where observed, he has yet to see a fracture system indicating well developed joints. Undoubtedly joints are present, but the evidence indicates that they are few, poorly developed, and widely spaced. In a mine subject to bumps, moreover, actual measurements of roof spans up to 225 ft between supports under a cover of about 800 ft have been made before roof failure occurred. Such spans signify strong roof.

In coal beds subject to rock bursts, the bottom rock is usually a sandy shale. A few tests (Table I) have been made on the floor rock of coal beds. Observations in mines indicate that they are usually weaker than roof rocks and that under load they show more plastic effects. Observation in ground subject to bursts invariably indicates a relatively strong floor highly resistant to heaving, although some heaving may occur.

Other factors listed as favorable to rock bursts are: 1) mountainous surface; 2) steeply dipping beds; 3) proximity of faults, folds, and other similar geologic structures. Many bursts have occurred in mines under mountainous country, although many bursts in mines under a surface with little relief indicate that thickness of cover, not relief, is the essential factor. In steeply dipping beds, many bursts occur in mines that are essentially flat, and rock bursts have been recorded in beds dipping as much as 35°.[3] Most rock bursts in the U. S. occur in beds that dip less than 10 pct. It is also true that most U. S. coal is produced from beds dipping less than 10 pct. Geologically, faults are regarded as providing stress relief, but in the vicinity of faults, as well as sharp folds, it would seem that residual stresses could be present. The fact that rock bursts occur in areas remote from faults and sharp folds suggests that their presence is not necessary for this phenomenon to take place. There have been many bursts close to faults and folds, and it may be assumed that occasionally such structures accentuate their occurrence.[4]

The conditions and circumstances under which they occur, coupled with the effects produced, leave

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* In the Crowsnest Pass coalfield, British Columbia, a rock burst is estimated to have released 1.8 million cu ft of methane.

little doubt that the fundamental cause of coal mine bumps is failure of brittle material (coal and adjacent rock) from excessive stress. This being so, knowledge of the following factors is essential if the origin of rock bursts is to be understood and if measures to prevent them are to be successful: 1) cause of the excessive stresses, 2) reaction of coal pillars to load, 3) capacity of rocks to store and release strain energy, and 4) effects of mining methods on the cause of the burst. Although knowledge of these factors is not complete, each will be discussed briefly.

STRESSES ABOUT MINE OPENINGS

Consider a small cube of coal (Fig. 1) situated in a bed within the earth's crust, the faces of the cube perpendicular and parallel to the earth's radius. It will be recognized that the coal is loaded by the rocks lying between the cube and the earth's surface. Assuming that the rocks are homogeneous, isotropic, and perfectly elastic, it has been shown—for cover up to several thousand feet thick—that the load per unit of area on the horizontal faces of the cube is wd and the load on the vertical face is $\frac{wd}{m-1}$. W, d, and m, respectively, are the weight of the earth's crust per unit volume, distance between the surface and the cube considered, and Poisson's number (Ref. 4, p. 199). If there are no crustal disturbances, and if the coal bed is thin in relation to its distance from the surface, it may be assumed with negligible error that this load is uniform throughout the bed.

Now, if the coal bed is penetrated by an opening, it will be found that stress concentrations are produced in the rocks forming the sides (pillars), roof, and floor of the opening. Assuming that the depth of the opening is more than three or four times its width and that the rocks are perfectly elastic, homogeneous, and isotropic, the following statements are theoretically true.

1) For a single opening the magnitude of the critical stress concentration in adjacent pillars depends on the following factors:*

a) Width of the opening divided by height of the opening. Variation of the critical stress at locations X with this ratio is shown by graphs in Fig. 3.*

b) Maximum stress depends on the geometric shape of the opening, that is, whether it is round, elliptical, rectangular, or square, and on the orientation of the axes of the opening with the force producing the stress.

c) The significant increase in stress extends into the solid rock or coal parallel with the opening for a distance about equal to the long width of the opening.

d) Maximum stress occurs in the plane of the wall of the opening (see Fig. 3).

e) Magnitude of the stress is affected by the value of Poisson's ratio of the rocks at the location considered.

2) In the case of multiple openings in the same bed, the maximum stress is not significantly affected if adjacent openings are farther apart than the sum of their widths.

* The stress values shown in Fig. 3 for R/H as related to S_1/S_v are the maximum at location X but are not necessarily the theoretical maximum stress on the opening.

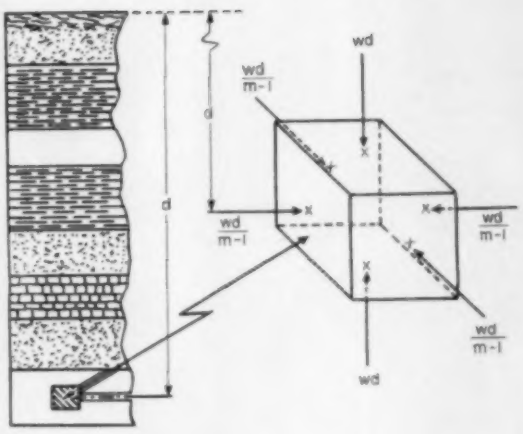


Fig. 1 (above)—*Stress conditions that prevail in coal beds before mining.*

Fig. 2 (below)—*Diamond drill logs showing roof strata over coal beds in which bumps have occurred.*

Table I. Physical Properties of Coal and Associated Rock from Beds in Which Bumps Have Occurred

Name of Bed and Location	Description of Rock Tested			Compressive Strength, Psi*				Young's Modulus of Elasticity Normal to Bedding, Psi*		Shear Strength Normal to Bedding, Psi**	
	Position	Type	Condition	Normal to Bedding	Probable Error ±	Parallel to Bedding	Probable Error ±	Secant Modulus‡	Probable Error ±	Strength	Probable Error ±
Upper Banner, Virginia	Roof	Sandstone	Dry	17860	367	16250	388	2,980,000	135350	4686	109
	Coal bed	Coal	Dry	3011	147			680,000	29000		
	Floor	Siltstone	Dry	3488	105	2073	242	1,709,000	471000	1383	74
	Floor	Siltstone	Wet	1250	22	909	42			1354	29
Pocahontas No 4, West Virginia	Roof	Sandstone	Dry	14741	254			5,290,000	407000	6653	305
	Roof	Sandstone	Wet					3,708,000	456000	5106	264
	Coal bed	Coal	Dry	2743	84			370,000	27000		
	Floor	Siltstone	Dry	7016	203	6647	306			2169	99
	Floor	Siltstone	Wet	4191	198	3972	211			1734	86
Harlan, Kentucky	Roof	Sandstone	Dry	13862	700	9519	195	3,000,000	592000	4833	233
	Roof	Sandstone	Wet							2615	155
	Coal bed	Coal	Dry	5138	224			567,000	38000		
	Floor	Siltstone	Dry	9003	529	7862	666	6,200,000	540000	2666	102
	Floor	Siltstone	Wet	5392	183	5389	421	4,600,000		2037	177
"C" or Taggart, Kentucky, and West Virginia	Roof	Sandstone	Dry	15550	528			3,670,000	371000	6233	261
	Coal bed	Coal	Dry	3122	314			580,000	81000		
	Floor	Siltstone	Dry	7587	1187			4,416,000	984000	3948	792
	Floor	Siltstone	Wet	6298	273	4740	698	6,466,000	330000	3786	168
Warcreek, West Virginia	Roof	Sandstone	Dry	19000	583			7,200,000	262000	4510	549
	Coal bed	Coal	Dry	2178	117			274,000	20000		
Lower Sunnyside, Utah	Roof	Siltstone	Wet	3869	564						
	Coal bed	Coal	Dry	4541	420	3860	380	487,000	34300		
	Floor	Sandstone	Wet	8967	355	6861	489				
Phalen, Nova Scotia	Roof	Sandstone	Dry	7700	540			7,548,000	86500	2660	251
	Coal bed	Coal	Dry	2197	305			259,000	39000		
Kenilworth, Utah	Coal bed	Coal	Dry	3642	140	4039	506	654,000	21000		
Marker, Virginia	Coal bed	Coal	Dry	5862	237						

* All rock specimens 2x2x4 in. or 1.5 diam x 3.0 in. All coal specimens 3-in. cubes.
** All specimens 1½x½ in. and 6 in. long approximately. Load applied normal to bedding.
† All specimens approximately 2x2x4 in.
‡ Secant drawn between zero stress and a point on the stress-strain curve at one-half ultimate strength.

3) If the openings are closer together than this, maximum stress occurs at the walls of the pillar forming the center of the group of openings, and this maximum stress is reached when the number of multiple openings is equal to or greater than five.*

4) In actual operations—because rocks are not perfectly elastic, homogeneous, nor isotropic and because local yield does occur—the maximum stress, as demonstrated by Phillips (Ref. 22, pp. 64, 65) and indicated by much experience in mining, does not occur at the walls of the opening but at a short distance inside the pillar. Furthermore, the maximum stress does not reach as great a value as theoretical considerations and laboratory experimental methods indicate.*

Actual distance inside the pillar, measured from the wall at which the maximum stress exists, has not been determined. Observations in many mines, however, indicate that this distance could have a minimum value of 1 to 6 or 8 times the bed thickness and that it is probably affected by width and height of the opening, depth of cover, and relative values of the elasticity and plasticity of materials comprising the roof, floor, and coal seam. The actual value of the stress produced probably lies between the theoretical maximum and the average stress concentration that would be produced if the weight of the strata above the unsupported opening were evenly distributed over the pillars for a distance equal to the opening width. In Fig. 3 an estimate of the actual stress distribution is shown by the dotted line. *This high stress area lying close to a mined out area is referred to as an abutment area or zone.*

Maximum stress in a pillar, as well as the stress distribution, as shown in Fig. 4, is influenced also by the width of the pillar relative to the width of the openings on each side of it. It should be noted that as long as the pillar is as wide as the opening the maximum stress is not materially lowered by making the pillar wider. However, making the pillar wider relative to the opening somewhat decreases the maximum stress and results in more of the pillar being under a lower stress. This is a factor that should be considered where the pillar, after being blocked out, will be subjected to the abutment loads of an advancing pillar line or longwall face.

In mining operations under heavy cover, it is not only necessary to realize that high stress areas are parallel to the mine openings and to have some idea of the intensity of the stress in the areas; it is also necessary to estimate how far these zones extend from the mined out areas. In the case of passageways, this can be done roughly by the rule given above. In the case of a goaf caused by pillar extraction or longwall operations, it cannot be done because it is not usually possible to measure the effective width of the goaf. However, it is recognized that increasing pressure will cause the rate of com-

* For example, the Pocahontas No. 4 coal bed in southern West Virginia is mined under cover up to 1800 ft thick. Development openings are driven 18 to 20 ft wide, and the bed is about 6 ft thick. According to the work of Panek, the tangential wall stress at mid-bed height under these conditions would reach values between 4000 and 5000 psi. Actual tests of 3-in. cubes of this coal show its compressive strength would be much less than this, perhaps as low as 400 psi. Yet the pillars usually show no evidence of failure in these headings.
In this same bed at a depth of 800 ft, the author has seen an opening 225 ft between supports lying between two old goaves approximately 1100 ft apart. According to theoretical considerations, the stress in the pillar walls would have been about 18,000 psi, yet the pillars showed little or no evidence of weight. In view of these observations, it is clear that the wall stress does not attain the maximum values indicated by theory.

Table I (Continued)

Modulus of Rupture, Psi**		Energy Stored, Lb per Cu In.		Poisson's Number† at		
Strength	Probable Error ±	At ⅓ Ultimate Strength in Compression	At Ultimate Strength in Compression	⅛ Ultimate	¼ Strength	½
2984	104	14	53			
		See Fig. 9	See Fig. 9			
858	86					
379	37					
2167	55	5	21	21	19	13
1730	57					
		See Fig. 9	See Fig. 9			
2922	107	83	33	9	6	4
2330	290					
		See Fig. 9	See Fig. 9			
1216	350					
958	127					
2846	108	88	33.1			
		See Fig. 9	See Fig. 9	3.4	3.2	3.1
2178	328					
1733	206					
4230	310	6.4	24.7			
		See Fig. 9	See Fig. 9			
		See Fig. 9	See Fig. 9	3.9	3.4	2.8
1120	34	3.0	11.8			
		See Fig. 9	See Fig. 9			
		See Fig. 9	See Fig. 9	3.7	2.9	2.4
		See Fig. 9	See Fig. 9	4.0	3.4	3.1

pression of pillars to increase. So by determining the distance ahead of a pillar line or longwall face at which an increased convergence rate starts, it is possible to obtain an estimate of the width of the abutment zone. Several investigations of this kind have been made.[7-25] A careful study of these indicates that the minimum width of abutment area adjacent to an extensive goaf varies from 200 to 300 ft when the cover is 800 to 2000 ft. It is also probable that the abutment area extends over a greater width in room and pillar work than in retreating longwall, and over a greater width in retreating longwall than in advancing longwall. In room and pillar work it probably extends over a greater width where the ratio of least lateral pillar dimension to pillar thickness is small than where this ratio is large.

From the foregoing discussion it is clear that in the average mine two or more abutment loads from mined out areas may be superimposed. In areas where this occurs, very high stresses in the pillars may result. Two such conditions are shown in Fig. 5.

Relief Induced by Drilling Holes: As explained above, an opening made into a stressed area multiplies the existing stress at and near the surface of the opening. Consequently the walls of a hole drilled into a highly stressed pillar area could be stressed two or three times as much as the pillar itself. Such a stress, therefore, probably would cause the walls to fail, resulting in a bump or a slow squeeze of material near the hole. The unit value of the stress generated in the walls of the hole is independent of the size of hole—a drilled hole of any size should cause bumping or squeezing. However, tests on coal specimens indicate that large specimens fail at a lower unit stress than small ones. Because of this, a large hole drilled into a pillar is more likely to cause stress release than a small one. This is borne out in practice. It should also be pointed out that coals vary markedly in compressive strength (see Table I), and for this reason the size and spacing of holes drilled for stress release purposes is likely to vary for different coals.

INFLUENCE OF PILLAR SIZE

The compression (e_1) a cube of coal undergoes when under constraint is given by Eq. 1:[27]

$$e_1 = \frac{P_1}{E} - \frac{P_2}{mE} - \frac{P_3}{mE} \qquad [1]$$

in which P_1 is the compressive force producing the strain e_1, P_2 and P_3 are forces acting perpendicular to each other and to P_1, E is Young's modulus, and m Poisson's number. In the mine pillar the force P_1 will be the load imposed by the overburden. Under this force the pillar will tend to expand in a plane perpendicular to the force. The expansion will be resisted by the frictional forces induced between the coal pillar and the floor and top rock as well as by the frictional forces between various members of the coal bed itself. These forces will provide constraint to the central part of the pillar, and under a given set of conditions the constraining forces will increase as the size of the pillar increases. Consequently, up to a pillar size in which these forces, P_2 and P_3, produce perfect constraint, the compression e_1 caused by a given value of P_1 will decrease with increasing pillar size. After the pillar size increases to the point where perfect constraint exists, e_1 will no longer be affected by pillar size but only by the physical properties of the coal in the pillar. Therefore, above this critical size under a given value of P_1, all pillars composed of coal having the same physical properties will compress the same small amount.

Pillars that have uniform physical properties and are less than this critical size under a given P_1 will compress by an amount inversely proportional to the size of the pillar. A stiff unbending roof such as overlies coal pillars in mines that develop rock bursts tends to compress all pillars by the same amount. Under these conditions the larger pillars carry more than their share of the load and become highly stressed. Therefore, mining practices that allow large pillars to be blocked out surrounded by smaller ones create situations that are favorable for the occurrence of rock bursts in the large pillars unless all pillars are above the critical size. Actual mining experience demonstrates that in a situation of this kind it is usually the large pillars that develop the rock bursts.

In addition to the constraint that develops because of pillar size, variation in the value of E and m can cause load concentrations. Actual tests[28] prove that there is considerable variation in the value of E within comparatively small distances in a given coal seam, and stress concentration can therefore be expected from this cause. Little information is available concerning the values of Poisson's number for coal or how it varies in a coal bed. Because it is reasonable to assume considerable

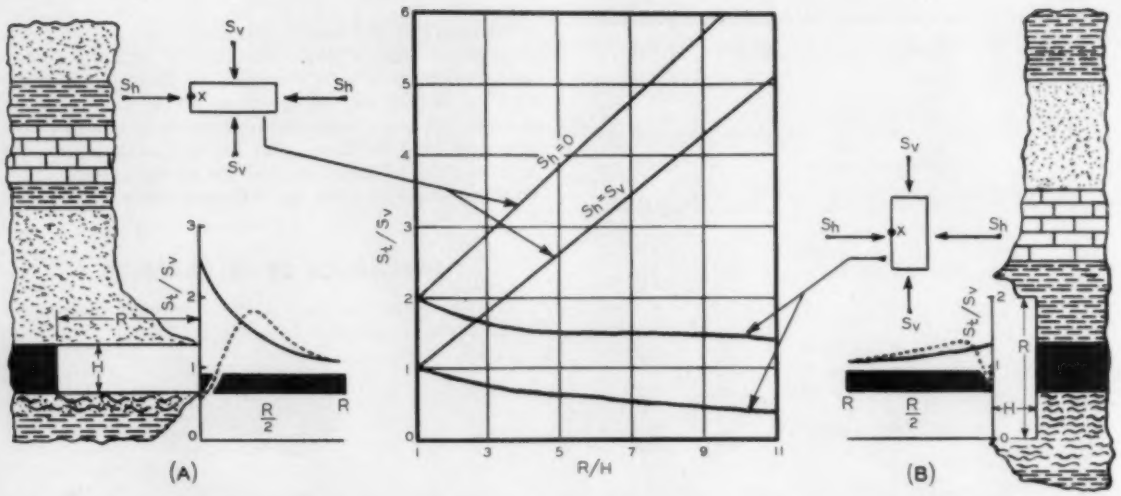


Fig. 3 (above)—*Stress conditions at mid-pillar height (X) in pillars adjacent to openings in coal beds. The graph showing the relation between S_t/S_v and R/H is based on experimental and mathematical investigations. The curves (A,B) showing the stress distribution (S_t/S_v as related to R) are estimated for the conditions $S_h = 1/3S_v$. Estimated distribution of theoretical stress is shown by the solid lines, for which the maximum and minimum values are theoretically correct and the values in between estimated. Estimated actual stress distribution is represented by the dotted curves showing the relationship between S_t/S_v and R. S_t = the tangential stress per unit area after the opening is made. S_v = weight of the overburden on the bed per unit area before the bed is disturbed by mining. S_h = horizontal stress in the bed before mining. R and H have the meanings shown. The information is based on Panek's work.*[4]

variation from place to place, stress concentrations are to be expected, increasing the probability of bursts. Any pillar or part of a pillar showing marked difference in hardness or physical structure is a likely location for a burst.

Impact Loading: Another factor, never proved to exist, that may cause high stress in mine pillars is impact loading,[18,19] which comes about because stratified mine roof spans an opening by acting as a series of beams or plates. Such structures impose high stress in support areas and perhaps relieve stress in areas behind the support. Then, as illustrated in Fig. 6, the failure of such a beam or plate or a failure of its support (such as a pillar or pillar remnant) can cause a high impact load on the pillar adjacent to the failed support, or, if the roof beam actually fails, on an area behind this pillar. Action such as this may cause a rock burst at the pillar line or at a place considerably removed from a pillar line.

Stress from Mined Areas: Stress concentration in an overlying or an underlying seam may be reflected in a bed being mined. Such concentrations in the overlying or underlying beds can come about from the various causes discussed above. A bed being mined can be affected, therefore, by abutment zones paralleling pillar lines or longwall faces or old goaves, or by stresses at unmined pillars in goaves in overlying or underlying beds. Whether or not the stress concentrations will have a serious effect depends on the distance between beds as well as the cover on the beds, and to a lesser extent, perhaps, on composition of the rocks between the beds concerned. Studies in the north of England indicate that the stresses induced by a goaf as wide as the "maximum pressure arch"* will extend a distance equal to twice the width of this arch above and below the seam in which the goaf exists. The width (see Fig. 7A) of the maximum pressure arch (W, expressed in yards) is given by Eq. 1:

$$W = \frac{d}{20} + 20$$

where d is the depth in feet from the surface to the bottom of the seam in which the width of the pressure arch is being computed.[20] That is, a bed lying at 800 ft would have a maximum pressure arch of 180 ft. This arch would produce stress concentration at its abutments for a distance of about 360 ft above and below the seam. The area affected in the seam being mined, however, would not necessarily be directly over or under the abutment of the arch in the seam above or below but would be located as illustrated in Fig. 7B. It will be apparent that many combinations of abutment loads can occur when more than one bed is mined. As illustrated in Fig. 11D, such concentrations can have serious results. Examples are shown in Fig. 7B. To these possible combinations should be added the stress multiplications that can occur owing to interaction of pillar lines and other causes when only one bed is mined.

STRAIN ENERGY AND ROCK BURSTS

Coal and associated rock are highly elastic under load (see Fig. 8) and when stressed have the capacity to store elastic strain energy. When these materials are not constrained, the amount of energy stored varies approximately as the square of the stress in the rock or coal and inversely as Young's modulus of elasticity for the material. Fig. 9 shows the energy coal is estimated to store at various ultimate strengths when not constrained. These curves present the result of tests that have been run on coal from seams that have and have not developed bursts. It will be noted that these seams do not differ discernibly in their capacity to store energy. It will also be observed that unconstrained coal can store comparatively large amounts of strain energy when

* Maximum pressure arch is the widest opening in a mined bed across which the main roof load can be transferred to supports at the perimeter of the opening.

highly stressed. At low stresses, however, the amount of strain energy stored per unit volume is small. When the coal is stressed to failure the violence of the failure, as well as actual measurements, indicates that a large proportion of this strain energy is released.[21]

When a rock is perfectly constrained and stressed in compression or tension, it stores strain energy as indicated by Eq. 2 (Ref. 22, p. 58):

$$W=\frac{1}{2E}\left\{P_1^2+2\left(\frac{P_1}{m-1}\right)^2-\frac{2}{m}\left[\left(\frac{2P_1^2}{m-1}\right)+\left(\frac{P_1}{m-1}\right)^2\right]\right\} \quad [2]$$

where W = strain energy stored per unit volume, E = Young's modulus of elasticity, m = Poisson's number, and P_1 = the principal stress acting.

Study of this equation shows that when the value of Poisson's number is 2, no energy is stored in the material stressed. Fig. 10 shows that when stressed at 2500 to 4000 psi and above coal has a Poisson's number of 2.* Consequently when perfectly constrained up to a stress of some 3000 psi, coal stores energy. When stressed above this figure, however, it stores no additional energy because of the increased stress. Therefore, pillars in which the constraint is small (when the ratio of pillar width to pillar thickness is less than 3 or 4) usually store energy nearly as an unconstrained body. When the pillar is large, the coal in the central part of the pillar is subject to high constraint and cannot store large amounts of energy, but the coal relatively close to a free face (for example, within four to six times the seam thickness) can store large amounts of energy. This is the part of the pillar, however, that is subject to high stresses (Figs. 3-5), and in this area the amount of energy stored is large. Consequently, if such a pillar is split or slabbed, mining may penetrate the highly stressed area storing large amounts of energy, and a severe burst may result. Also, when large pillars are surrounded by smaller ones, and the abutment area of an advancing pillar line moves over the large pillar, the resultant stress may become great enough to fail a part or all of the pillar containing this high-energy coal and a very serious burst can result.

As pointed out before, coal which can develop only comparatively low stress stores only small amounts of strain energy and should fail nonviolently. Thin-pillar mining systems therefore have been devised in the hope of eliminating bursts. Although they have not accomplished this, some of these systems have been successful enough to justify further experiment. In this connection it should be kept in mind that 3-in. test cubes of strong coal usually fail violently, and in several instances pillars only two or three times as wide as the bed is thick have failed with enough violence to injure workmen seriously (see Fig. 11B). At present it seems wise to limit these experiments to weaker coals such as the low and medium volatile seams, and even here the system should not be used to extract large pillars surrounded by smaller ones or in other conditions where the coal bed may be under unusually high stress.

Roof rocks when stressed can store energy in addition to that stored by seams. Tests indicate that under the same compressive strength as coal, these beds do not store as much energy per cubic inch of volume (see Table I). But these rocks also store

* Note that coals tested and listed in Table I do not attain a Poisson's number of 2 at this stress, although some are close.

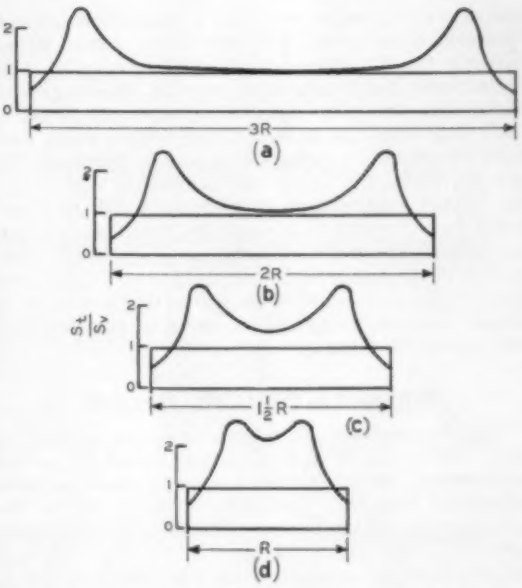
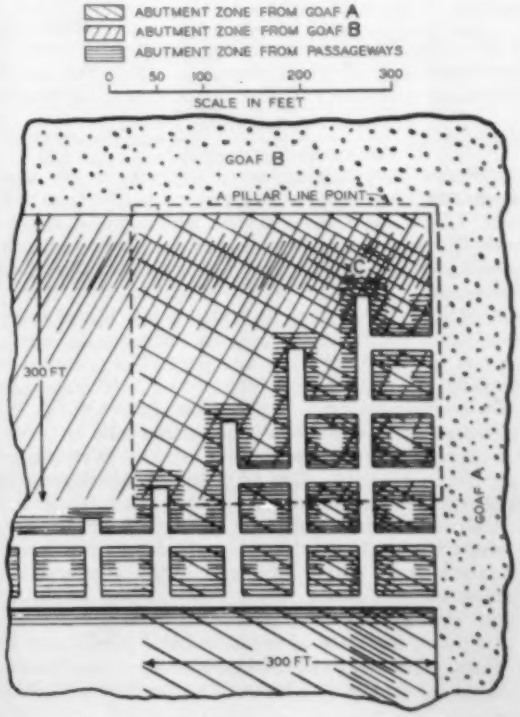


Fig. 4 (above)—*Pillar stress magnitude and distribution as affected by width of the pillar relative to width of opening (R). As the width of the pillar varies from one to three times the width of the opening it supports, the maximum stress decreases very little, but the stress distribution is changed.*

Fig. 5 (below)—*Abutment zones paralleling passageways and extensive goaves in a coal mine. In abutment zones the closest spaced lines indicate areas of highest stress. Area within the dotted line is defined as a pillar-line point and is that area lying within 200 to 300 ft of two or more goaves. The abutment zones from two or more openings may be superimposed, resulting in very high stress areas. Room C is being driven in such an area.*



energy when stressed as plates or beams when spanning mined out areas. The amount of energy stored varies as the fifth power of the span developed. Also a cantilever beam can store about 36 times as much energy for the same span as a beam supported at both ends (Ref. 22, p. 59). These beams when they rupture probably release a great amount of this energy, which forms part of the energy that causes the impact loads discussed previously. For this reason it is important to prevent the formation of long spans acting either as beams or plates of unsupported roof, especially if the span is of a cantilever type. If the formation of long roof spans cannot be avoided, measures should be taken to prevent their instantaneous failure.

STRENGTH OF MINE PILLARS

Many investigations of the strength of coal in small specimens (2 to 4-in. cubes) reveal a strength of 1500 to 8000 psi. As the size of the test specimen increases, however, the unit strength drops. For example, as a 5-ft cube the Pittsburgh seam near Bruceton, Pa., has a strength of 695 psi, but as a 2½-in. cube its strength is 2486 psi (Ref. 23, pp. 1, 12). Gaddy[24] investigated the strength of cubical coal specimens and found that the ultimate strength of the cubical specimen tested varied inversely as $\sqrt{\text{dimension}}$ and that the general equation for the strength of a cubical specimen is

$$S \frac{K}{\sqrt{D}} \qquad [3]$$

in which K is a coefficient depending upon the physical characteristics of the coal bed and D is the dimension of the cube in inches.

Mueller[25] has demonstrated that a comparatively small confining stress greatly increases the strength of coal. The Scranton Engineers' Club[26] determined that the strength of anthracite varies as $\sqrt{\frac{1}{\text{thickness}}}$ of the pillar, other things being equal. The author[27] has demonstrated experimentally that for small laboratory specimens of bituminous coal the strength varies as $\sqrt{\frac{\text{width of specimen}}{\text{thickness of specimen}}}$ and Greenwald[28] and others have demonstrated experimentally that essentially the same relationship holds true for much larger specimens tested under mine conditions. Furthermore, the present writer's experiments[27] demonstrated that, under laboratory conditions, after the ratio width of specimen to thickness of specimen increased above 4.9 the weaker coals, such as the low volatile bituminous coals, did not fail abruptly but squeezed. The ratio was increased to 8 or higher before the stronger high volatile coal squeezed rather than failed abruptly. This increase in strength as the ratio width to thickness increased was undoubtedly due to the effects of a confining pressure such as noted by Mueller. The confining pressure builds up in laboratory specimens as well as in mine pillars, because of the friction between the coal and the top and bottom rocks and the tendency of coal to expand horizontally under a vertical load.

The strength of coal pillars in mines, however, is not given by tests of small cubical specimens or by tests of cubical specimens having edge dimensions equal to bed thickness. On the basis of laboratory experiments and studies of loads supported by pillars in coal mines for periods up to 40 years, Holland and Gaddy[21] have suggested that the average ultimate strength of a coal mine pillar can be represented by Eq. 4:

$$S = \frac{k\sqrt{L}}{T} \qquad [4]$$

where S = ultimate strength of coal pillar, psi.
k = coefficient depending on the coal bed.
L = least width of the pillar in inches.
T = thickness of pillar in inches.

The exact $\frac{\text{least width}}{\text{thickness}}$ ratio over which this equation applies is not known, but it seems likely that it would apply for values between 0.75 and 15. Above a ratio of about 15 the pillar probably becomes indefinitely strong and fails only by squeezing, i.e., plastic flow, but it should not be assumed that a pillar having an average stress below the ultimate value given above will not fail abruptly. Such a failure may be explained by the rim stress in a pillar (Fig. 4). This concentration of stress may cause a pillar to fail at the edge even though the main body of the pillar does not. In the low volatile seams of southern West Virginia three pillars approximately 150 ft on a side and 6½ ft thick failed abruptly and with great violence under an overburden of 800 to 1200 ft, but it is believed that these failures were initiated by rim failures. Coeuillet[27] places the minimum width of a pillar that will not fail abruptly at greater than 150 ft.* The actual strength of coal pillars is still in doubt, but it may be safe to make the following assumption:

1) For ratios of $\frac{\text{least width}}{\text{thickness}}$ between 0.75 and 15 the unit strength of a coal pillar may be given by the equation $S = \frac{K\sqrt{L}}{T}$.

2) It should not be assumed that any pillar less than 250 to 300 ft on a side in a bed 6 to 8 ft thick under an excessive load, concentrated or otherwise, will gradually fail by squeezing rather than by shattering in whole or in part.

Actual size of pillars to be used depends as much on loading conditions as on strength of pillars. Fig. 3 shows the theoretical loading as well as an estimate of the probable loading of the pillar immediately adjacent to the passageway. It will be noted that the zone of disturbed stress about a passageway is estimated to extend a distance into the pillar about equal to the width of the excavation. Consequently, if two passageways driven in a bed are separated by a distance equal to their combined widths, their zones of disturbed stress should not influence each other (see Fig. 4). In consideration of this fact, Panek (Ref. 5, p. 39) has suggested that pillars should have a minimum width equal to the combined widths of the passageways that delineate the

* The key to this situation may be the coefficient of friction, under extremely high loading conditions, between the coal and the roof and floor rock or within the coal itself. The coefficient when the coal is loaded beyond a critical unit load, or following a very small movement of the coal relative to the top and bottom rocks, may suddenly decrease and permit an instantaneous decrease of the constraining force, thereby permitting a pillar burst to occur. In this connection the brown stains on the roof, common to all burst areas, indicate relative motion between the coal and top rock under high stress conditions at the interface. More research is warranted on this phase of bursts.

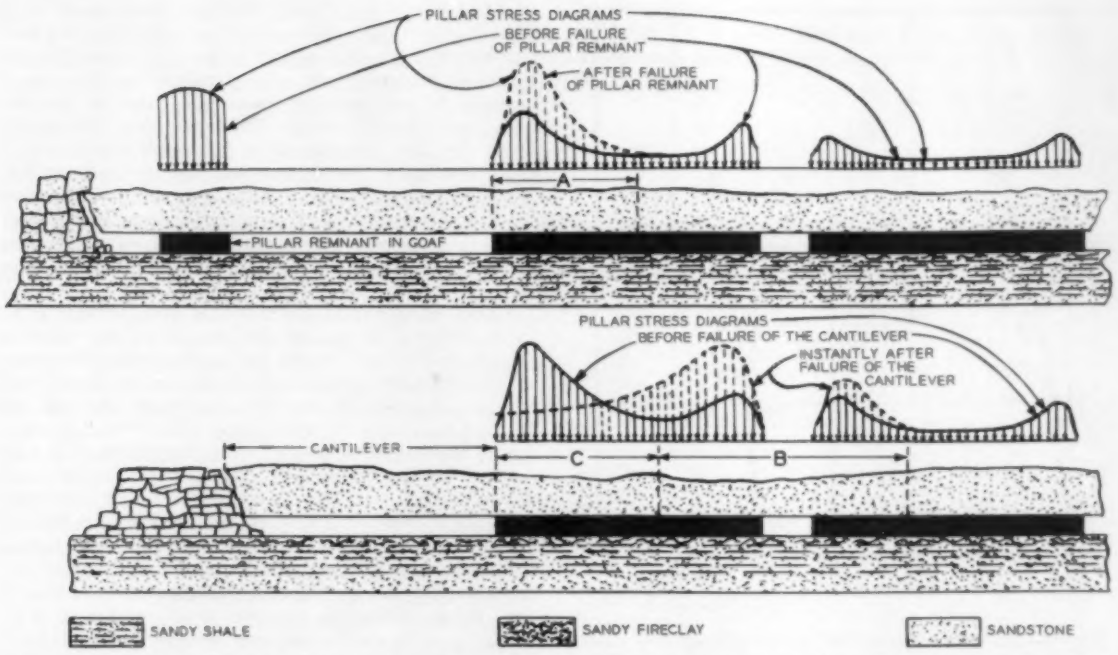
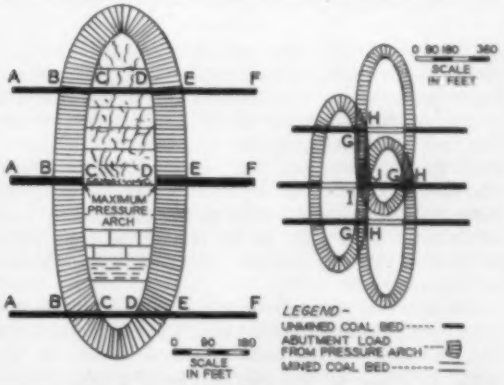


Fig. 6—*Impact stress in coal beds. If the pillar remnant fails suddenly, part or all the load it supported is instantly transferred to the pillar at A and may produce a high impact stress that might cause a shock bump at A, see upper drawing. As the span of the cantilever increases due to mining, the stress at C also increases as shown in lower drawing. If the span becomes long, a pressure bump may occur at C. If the cantilever fails suddenly, the stress at C is decreased, but a high impact stress may be caused in the area B and could result in a shock bump in this area.*

Fig. 7—*Abutment areas adjacent to the maximum pressure arch. Part A shows the general properties of the arch. DE is the high stress area in the abutment. Note that it is acting in all beds across which the arch extends. CD is a low pressure area, and in EF the stress in the coal bed is only a little greater than that which prevailed before the middle seam was mined. Part B illustrates how abutment loads from areas mined in overlying and underlying beds may be superimposed. At IJ three abutment loads act, resulting in a very high stress in the rocks. At GH point two abutment loads are superimposed. There are many other possible combinations.*



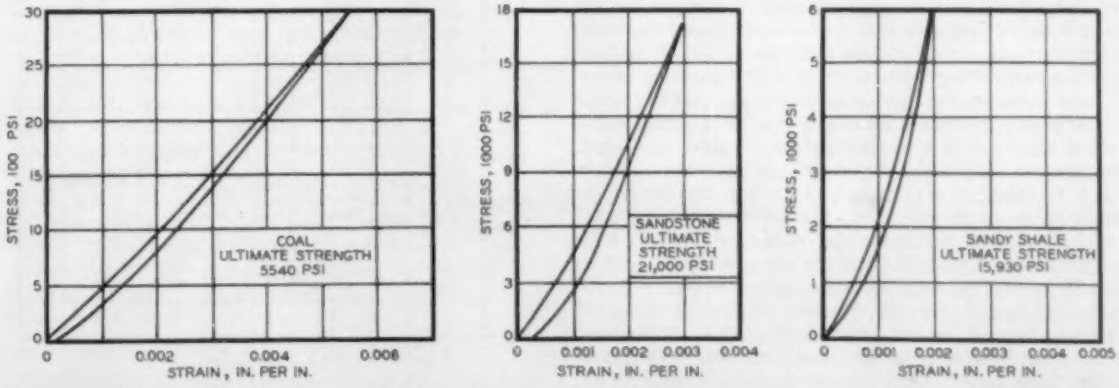


Fig. 8—*Typical stress-strain curves for shale, sandstone, and coal under a compression load. Note that all three show high elasticity under a load applied for a short time, although strengths range from 5,540 to 15,930 psi.*

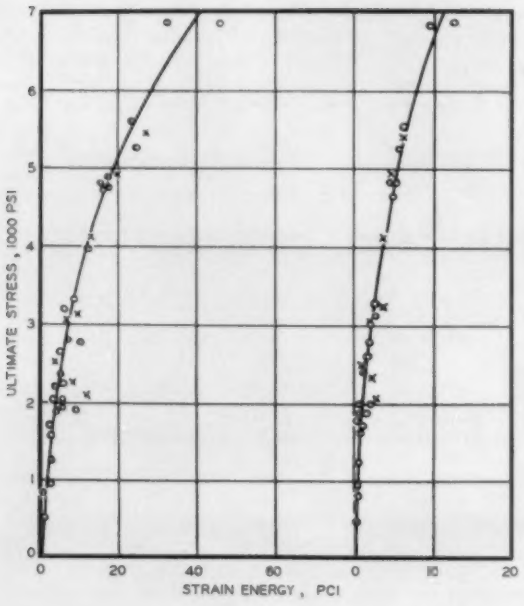


Fig. 9—*Energy stored by coal when stressed and unconstrained. Circles represent coal from beds that have not developed bumps and crosses the coal from beds that have. Curve A shows the energy estimated to be stored at the ultimate strength of the coals tested. Curve B (at right) shows the energy stored when the coal is stressed to one half its ultimate strength.*

pillars. Actually, the minimum width of pillars should be somewhat more than this, as the coal at the edge usually is destressed and sometimes failed for a distance of one to three times the thickness of the bed. Furthermore, the pillar is liable to be subject to the zone of very high stress advancing ahead of a pillar line. Pillars should be designed to take care of this increased stress, and pillars loaded as A and B of Fig. 4 are loaded will be able to carry this increased stress better than pillars loaded as C and D are.

Since there is no certainty that small pillars will give protection against bursts, it seems wise at present, because of the factors listed above, to make them as large as possible. In most cases, legal requirements of practical considerations will limit room pillars to a maximum side dimension of 80 to 100 ft. A square pillar is the best shape. Because of the tendency of pillars to load up when larger than surrounding pillars, all should have the same dimensions. Furthermore, since the maximum stress on a pillar increases as the width of the passageways that cut it out, passageways should be kept as narrow as practicable. Certainly in beds up to 6 or 8 ft thick, the passageway should not be more than 14 to 16 ft wide.

The manner in which the pillar is recovered is important. It should be kept in mind that under heavy cover the edge of the pillar next to an extensive goaf is usually crushed and/or destressed for a considerable distance into the pillar. Recovery lifts therefore should be taken off the goaf side. Also, for a given area of recovery per lift this practice decreases the unit strength of the pillar the least. Pillars should not be split, as this causes the greatest decreases in unit strength for a given area of recovery (Ref. 28, p. 60). In addition, a place driven through the pillar must pass through the areas of highest stress and greatest stored energy content where burst probabilities are the largest. The pillar should not be slabbed on the side away from the goaf, because here the area of destressed coal paralleling the passageway is narrower, and it is highly probable that mining operations will penetrate it before the stresses have been dissipated. Even in open end operations, the slab taken from a pillar should be no wider than 12 to 14 ft in beds up to 6 or 8 ft thick.

Under some conditions it would considerably promote safety if the destressed area of a pillar next to an extensive goaf could be made wider. Experiments in South Africa indicate that in the hard rock of the gold mines on the Witwatersrand blasting can be used to widen the destressed area.[35,36] In this case the destressing is done by boring deep holes into and normal to the face and blasting them with just enough explosive to fracture the rock without shooting it down. These destressing holes are drilled 3 to 5 ft apart and 10 ft deep. To date the practice seems to have reduced the number and severity of the rock bursts that occur. Limited experience in coal mines with similar operations suggests that bumps can be controlled and induced at opportune times. Solid shooting in coal mining is fraught with danger, but in some cases where the bump hazard is high the practice might be justified if adequate precautions were taken.

WHERE ROCK BURSTS OCCUR

In a survey of the occurrence of coal mine bumps fairly complete data have been gathered on 163 pillar bursts.* This information has been analyzed to find out where and under what mining practices bursts occur. Results of the analysis are presented in Tables II and III.

* This has continued the survey made by the U. S. Bureau of Mines and reported in *Bull. 535*.[22]

Examination of Table II will reveal that about 80 pct of all bursts studied were located definitely or probably on a pillar-line point (see Figs. 5 and 11 A and C). To appraise properly the significance of the large proportion of bursts occurring on points, it would be necessary to know the proportion of

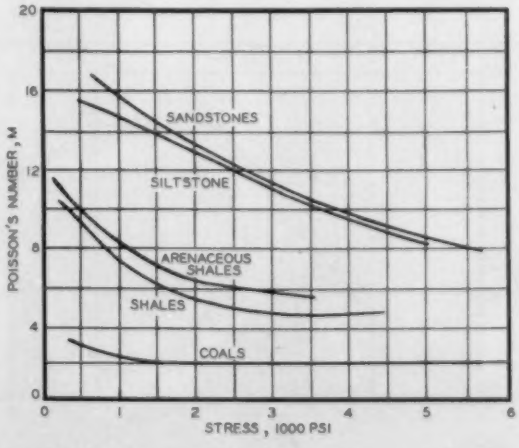


Fig. 10—*Poisson's number for various coal-measure rocks, varying stresses. (After Phillips, Ref. 22, p. 62).*

coal produced from these areas. This information is not available, but inspection of a great many mine plans indicates that much less than half the coal was produced from the areas classed as pillar-line points. It is therefore readily apparent that the likelihood of bursts occurring on points is much higher than the probability in other areas. These points or projections, as explained above, are the areas in which mine pillars are subjected to the greatest loads and highest stresses. Furthermore, nearly all the bumps studied occurred in or close to areas where pillars were being extracted.

Table III presents results of the analysis of the bursts as related to mining operations. To develop the full significance of the results, it is also necessary to know the relative amount of coal produced from each operation. As in the case of pillar-line points, this information is not available, but some general estimates can be made. For example, 19 pct of the bursts occurred in open end pillar extraction. Apparently this operation is often associated with bursts. When it is realized, however, that in mines subject to rock bursts most pillars are recovered by open end methods and that such methods probably account for 50 pct of the coal produced, it will be seen that the operation is relatively safe. Operations other than open end—such as slabbing and splitting in the abutment area, development in abutment areas, and pillar-and-stall recovery—account for 45 pct of the bursts, although such operations probably produce less than 25 pct of the coal. It should also be noted that fewer than 1 pct of the bursts studied occurred in development that was done out of the pillar-line or goaf-line abutment area. This development was done under cover just as heavy as that which prevailed over the abutment areas of pillar lines and goaves and probably accounted for at least 25 pct of the coal produced.

Table II. Location of Bumps

Location	Number	Percent of Total
On pillar line points	111	68
Probably on pillar line points	23	14
Probably not on pillar line points	7	4
Definitely not on pillar line points	19	12
Insufficient information to classify	3	2
Total	163	100

The rock bursts classified as district bursts in Table III are those that affect several pillars simultaneously (see Figs. 11C and 12B). Such bursts in the past usually have been called *shock* bumps. It is important to note that 80 pct of these occurred in the area defined as a pillar-line point. While in many cases these probably are rightly named shock bumps, it should be observed that all were in areas where pillars are subject to very high static loading. The chances are quite high that some of these actually were not shock bumps as usually defined, but pressure bumps. It is also possible that failure of one pillar from excessive pressure may have caused stress disturbances resulting in failure of other pillars that were stressed close to the point of failure—a kind of chain reaction.

PREVENTION OF ROCK BURSTS

Rock bursts in coal mines are best prevented if the mine is planned from the beginning to eliminate their occurrence in every way possible. This involves thorough study of the natural conditions, especially cover thickness and the make-up of that cover with regard to strong strata as well as the rocks forming the floor. The following points should be given particular attention:

1) In complete-extraction operations all the coal should be recovered. The all too frequent practice of leaving pillars or pillar remnants in the goaf should be eliminated. The load-supporting capacity of those that cannot be recovered should be destroyed insofar as possible, to lessen the danger of bursts from failure of beam or plate support areas.

2) Pillar lines should be orientated with the natural fracture system of the roof to promote caving in the goaf, so that long spans will not form over goaf areas. If the formation of long spans cannot be avoided, steps should be taken to prevent their rupture. Cribs used judiciously have been employed successfully to do this.

3) Development in abutment areas of pillar lines or old goaves should be avoided. This can be done by keeping active development more than 200 to 300 ft ahead of the pillar line or from the goaf edge. Furthermore, places making development in abutment areas should not be driven toward pillar lines or old goaves. This means that development places are always being advanced toward areas of lower stress. Fig. 13 shows one method that will avoid both mining on points and development in the abutment zone of old goaves.

4) Extraction should be planned to eliminate points formed by converging pillar lines or pillar lines on an old goaf and advancing parallel to the old goaf (see Fig. 13). It is particularly important to eliminate, whenever possible, the practice of leaving a set of entries protected by heavy barrier pillars 200 to 300 ft wide between mined out areas.

5) Pillars should be recovered by open end methods, and the *lift* removed in each cycle should

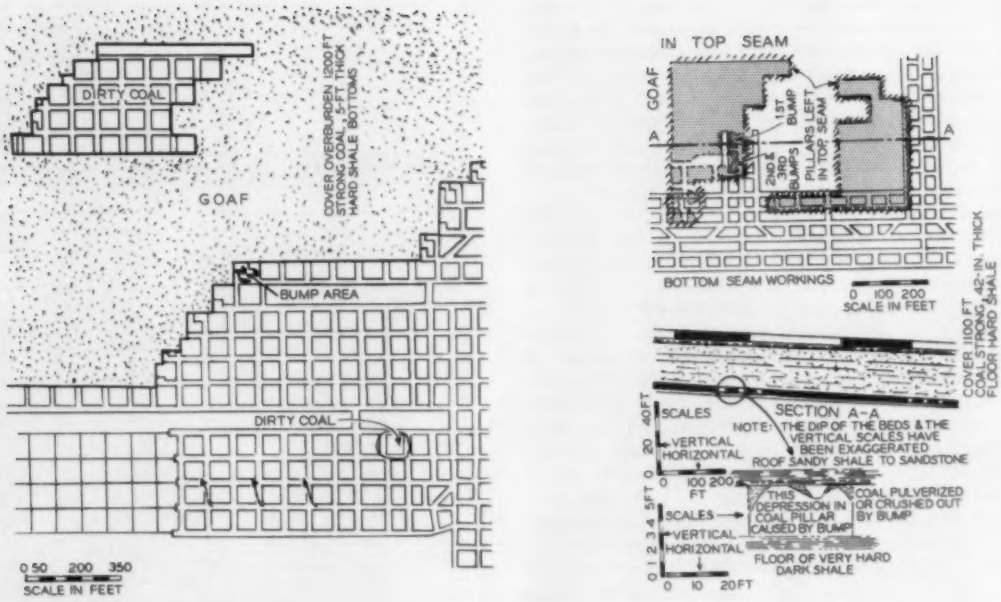
Continued on page 1004B

Table III. Mining Operations Being Performed or Conditions Existing When Bumps Occur in Coal Mines

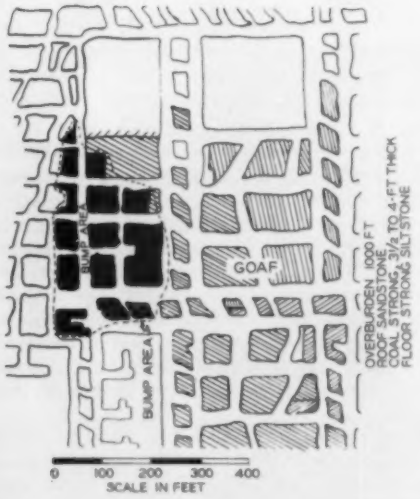
Mining Operation Being Performed (Col. 1)	Number of Bumps (Col. 2)	Percent of Total (Col. 3)	Bumps that Occurred on Pillar-Line Points: Number* (Col. 4)	Bumps that Occurred on Pillar-Line Points: Percent Number in Col. 4 is of Number Listed in Col. 2 (Col. 5)
Open end pillar extraction	31	19	20	65
Slabbing pillars in abutment areas	35	21	26	74
Developing in abutment areas	30	18	24	80
Splitting pillars in abutment areas	9	6	9	100
Pillar not being mined and back from extraction line	16	10	9	56
District bumps	10	6	8	80
Pillar and stall pillar recovery	7	4	4	57
Pillar being mined, bump not at face	2	1	2	100
Recovery of pillars surrounded by goaf and small pillars or partly mined pillars	3	2	3	100
Pillar on completed goaf line and not being mined	5	3	5	100
Miscellaneous	4	3	2	50
Insufficient information to classify	11	7	8	73
Total	163	100		

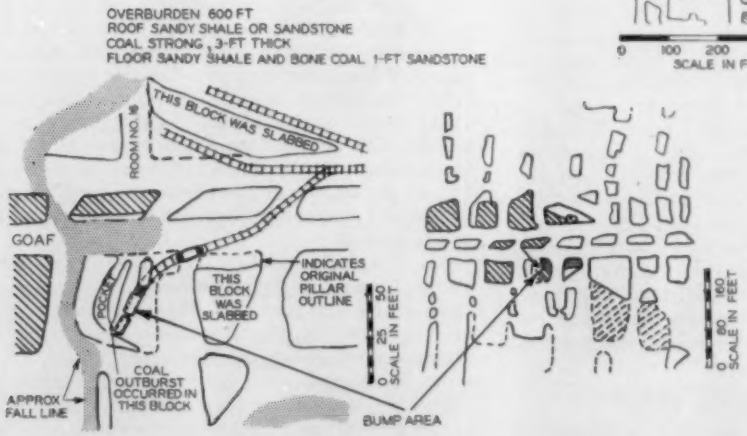
* Only part of the bumps classed as probably on pillar line points are included in this count.

Fig. 11

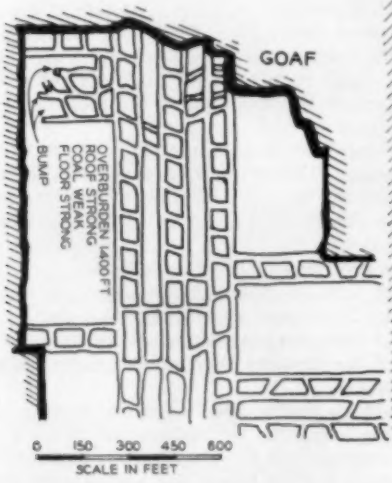


A. (ABOVE)—Occurrence in pillar in a point area where two abutment loads impinged on the pillar, which was being recovered by open end lifts driven parallel to first one goaf and then the other. B. (BELOW)—This bump in a pillar only 12 ft wide resulted in fatal injuries. In many coal beds a thin pillar may bump. C. (RIGHT)—A district bump, which affected 14 pillars. Note that part of the pillars that bumped were in a point area. Bump may have been set off by driving the place shown (in which a cut had been completed a few minutes before failure occurred) into the large pillar. An estimated 2000 to 3000 tons of debris were produced by the failure. D. (UPPER RIGHT)—This bump occurred as development places in a lower bed were being driven under a pillar in a mined out upper bed. Pillar in upper bed was carrying multiple abutment loads.

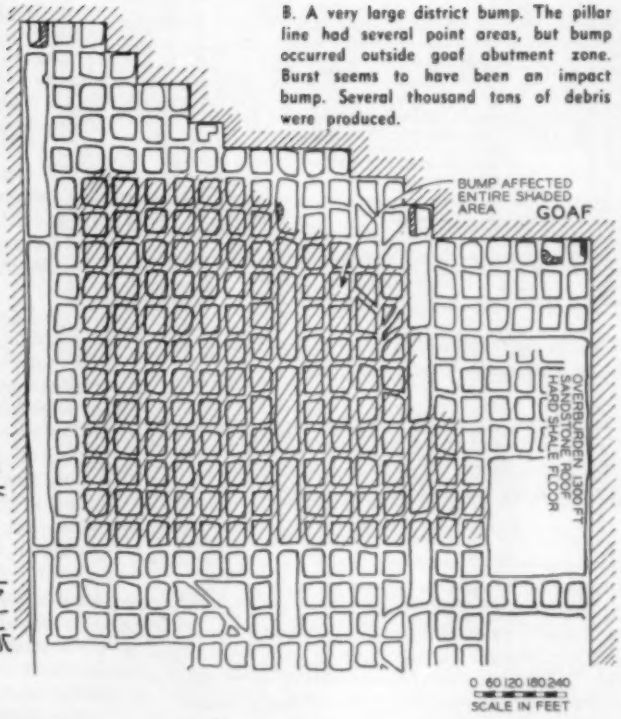




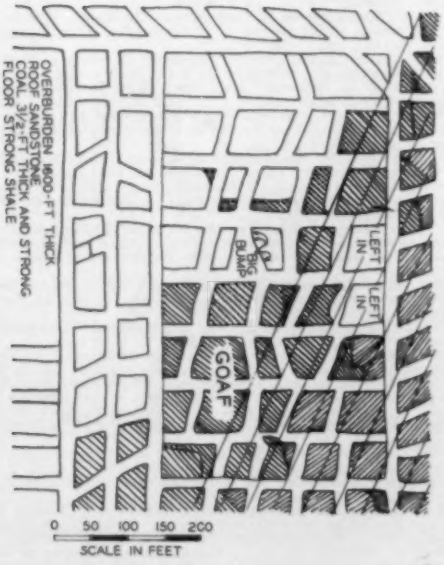
A. Bump occurred as rooms were being developed in point area. This point carried two heavy abutment loads and may have carried a third lighter abutment load from the area developed by entries.



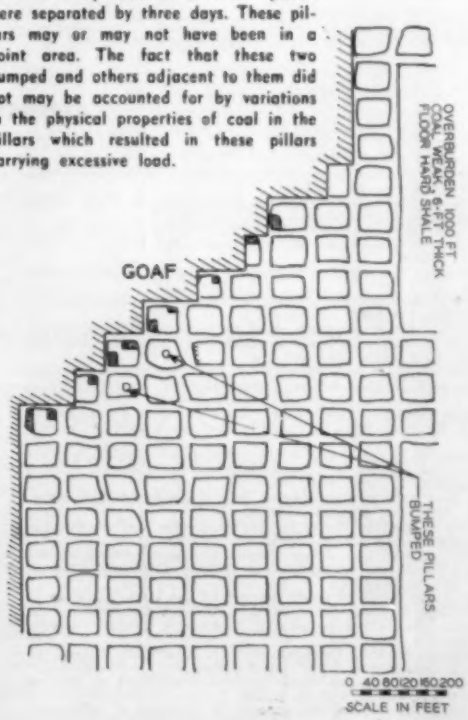
B. A very large district bump. The pillar line had several point areas, but bump occurred outside goaf abutment zone. Burst seems to have been an impact bump. Several thousand tons of debris were produced.



C. Bump occurred as pillar in a point area was being slabbed from the outby side toward the goaf. Three abutment loads probably impinged on this pillar, two from goaf and one from large area developed by slabbing.



D. The bump failures of these pillars were separated by three days. These pillars may or may not have been in a point area. The fact that these two bumped and others adjacent to them did not may be accounted for by variations in the physical properties of coal in the pillars which resulted in these pillars carrying excessive load.



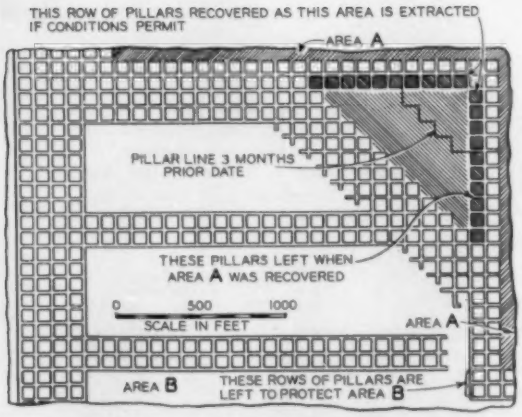

THIS ROW OF PILLARS RECOVERED AS THIS AREA IS EXTRACTED IF CONDITIONS PERMIT
AREA A
PILLAR LINE 3 MONTHS PRIOR DATE
THESE PILLARS LEFT WHEN AREA A WAS RECOVERED
0 500 1000
SCALE IN FEET
AREA A
AREA B
THESE ROWS OF PILLARS ARE LEFT TO PROTECT AREA B

Fig. 13—*Planned extraction provides a mining system to be used under conditions that cause bumps.*

not be more than 12 to 14 ft wide. The loose end of the lift (the end next the goaf) should be kept ahead of the tight end (next the pillar) and not more than one lift should be worked on any pillar at the same time.

6) To give the support needed, pillars should be as large as practicable. Also, large pillars provide great resistance to abrupt failure as well as less face through which highly stressed areas, due to variations in physical properties of coal, can fail abruptly.

7) Pillars should be uniform in size and shape (see Fig. 13) to prevent concentration of excessive loads on large pillars or pillars of different shape.

8) Pillars should not be split in abutment zones nor slabbed except on the goaf side in areas of high stress. If rock falls in existing passageways necessitate splitting or slabbing a pillar, slabbing offers less chance of a burst. Slabs should be driven as narrow as possible, and special precaution should be taken to protect the miners, especially the cutting machine crew.

9) In areas where overstressed pillars are known to exist, they can be drilled with large-diameter drills to induce a bump and relieve stress in the pillar. Again, it is important to give adequate protection to the drill crew. It should also be noted that this method does not give protection against a shock bump or district bump, illustrated in Figs. 11 C and 12 B.

10) In mining where the bump hazard is great and where only pillar-and-stall recovery can be used, drilling and blasting the solid side of the pillar could increase the safety of driving the next stall. This practice should be attempted only where is conforms to legal requirements and adequate safety precautions are adopted against the hazards of solid shooting.

Finally, our understanding of rock bursts is by no means complete. More research is needed, especially with regard to stress distribution in coal seams and adjacent rocks as influenced by mining methods or practices. Better means are needed to predict accurately the time and place of rock bursts. As matters stand now, it is possible only to point out locations where rock bursts are most likely to occur. A comprehensive research program would do much to clear up some of the mystery surrounding this problem of deep mining.

It should be emphasized that for mining under deep strong cover, no absolute preventative of rock bursts in coal mine is known, but the measures listed above should greatly lessen the probability of their occurrence and decrease the severity of rock bursts that do occur.

Discussion of this article sent (2 copies) to AIME before Oct. 31, 1958, will be published in MINING ENGINEERING.

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Reports of Your Technical Society

FEBRUARY ANNUAL MEETING 1008

► Students and education problems continue to concern the mineral industries. While others talk and plan **WAAIME** is acting. For a report on the high school student program recently inaugurated by the Woman's Auxiliary, turn the page.

Last minute plans are fomenting for those fall meetings you are planning to attend.

1) Salt Lake City is the setting and this month the time for the Rocky Mountain Minerals Conference _____ 1013
2) Program changes and committee personnel for the AIME-ASME Joint Solid Fuels Conference _____ 1007
3) The Mid-America Minerals Conference and prominent guest speakers 1009

Why belong to SME of AIME? A leading member of AIME, prominent in his industry, gives reasons and testimonial in *Coal News* on page 1014.

Don't forget that **OCTOBER IS GUEST NIGHT AT YOUR LOCAL SECTION.** When you take an associate to this meeting, help him fill in the SME application blank, reprinted on pages 1015 and 1016 of this issue. Our slogan—*Every mining man should belong to SME of AIME.*

NEWSLETTERS . . .
- Coal, page 1014
- Rock in the Box, page 1013

Watch next month's issue for news of the Southeast Section's annual fall meeting in Atlanta, November 14 and 15. Rumor has it that this important technical event will wind up with a rip-roaring football skirmish in true Georgia Tech style.

Quincy Hoist—AIME Upper Peninsula Section joins other civic groups to preserve an historic mining site. For a report on this project, turn to page 1010.

How Does SME Spend Its Money?_____ page 1011

SME Preprint Availability List, Page 948

New United Engineering Center—fund campaign and other plans progress. For this story, see page 961. What is a member's responsibility? Read *Drift* on page 957.

Proposals for Membership
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These forms appear on page 1018 for your convenience

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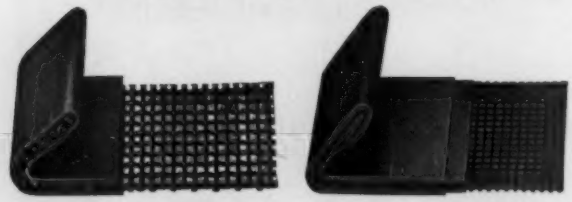

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While Others Still Talk, WAAIME Acts

The women of AIME are demonstrating their concern for the future of engineering in an active program to ensure engineers for tomorrow. The Western Pennsylvania Section of the Woman's Auxiliary is sponsoring a *Pilot Student Venture* as its first step in a new program of secondary school student guidance and counseling. Their purpose is to stimulate interest in the neglected fields of mining, metallurgical, and petroleum engineering.

Realizing that the lack of interest on the part of the students today in these vital science fields stems mainly from a lack of knowledge of the challenges these professions offer, WAAIME hopes to awaken enthusiasm by showing students actual mining operations. On July 14 through 19 the first excursion took place under the guidance of G. R. Spindler, director of the School of Mines at the University of West Virginia. Ten science-minded sophomore high school students were taken to the University, given proper mining attire and equipment, and guided to various mining properties for the five days.

First Student Excursion

The Christopher Coal Co. at the New Humphrey Mine was the first stop. Most of the time was spent underground observing the equipment at work in this latest development of the area. The Mountaineer Coal Co. in the Fairmont area demonstrated the preparation plants and outside installations, including the new Loveridge mine, which is the most modern development in that area. Stripping and auger mining operations at the Hanna Coal Co., St. Clairsville, Ohio, were also viewed before the students returned to the University.

A final day was devoted to discussion, summarizing the significance of the excursion, and presenting the academic program to familiarize the students with the University. The boys were treated to a country club dinner, with prominent mining men on hand to answer their questions and encourage their interest.

WAAIME Objectives

WAAIME believes that this direct exposure to mining operations, to well known engineers, and to the facilities colleges have to offer will encourage students to consider careers in mining and metallurgy at a time when preparation for college is at hand. Similar projects are being planned to acquaint students with the petroleum field. A follow-up program of literature, films, and personal interviews will be conducted by the auxiliary until these students have entered college and decided upon their careers. The women who have initiated this program understand the need for guidance at an early stage, when high school courses are being decided, and for continual interest and encouragement from the mining industry itself while the students are considering their future course.

WAAIME also realizes that material aid is often necessary, beyond interest and encouragement, and they are prepared to provide scholarship assistance where funds for academic training in these fields are not available to worthy students. This way they can have the satisfaction of knowing they did the job all the way! In addition, the SME Coal Division scholarship program provides $300 to $400 yearly to more than 15 deserving students of engineering, and several more are to be selected this fall. These scholarships are given over the four-year period with the understanding that satisfactory records must be maintained. The record of the students who have continued under this program has been good.

Plans to expand the WAAIME project include setting up camps to familiarize students with opportunities in the field, with guidance from retired engineers and inspiration from leaders such as George M. Humphrey, Herbert Hoover, Louis S. Cates, and others. A National Committee has already been established to offer similar programs on a nationwide scale next summer. The women are hard at work to provide vital opportunities for the engineers of tomorrow.

The 21st Annual Joint Solid Fuels Conference Will Compare Power Today and Tomorrow

The 21st Annual Joint Solid Fuels Conference is in final stage of preparation for its opening day, October 9. Convention goers will gather at the famous Chamberlin Hotel, which crowns the tip of historic Virginia Peninsula.

The general theme of the Conference is *The Export Coal Market* and this will be highlighted by a waterside tour of the coal loading facilities of the three Pocahontas coal-carrying railroads, the Chesapeake & Ohio Railway, the Norfolk & Western Railway, and the Virginian Railway. This Hampton Roads Harbor Tour will also include the Newport News Shipbuilding & Dry Dock Co., Norfolk Naval Base, and Fort Monroe.

The Chamberlin Hotel is readily accessible by air, rail, bus, or car and is located at Fort Monroe on U. S. Route No. 258. There is C & O Railway service to Newport News and airline service to Patrick Henry Airport, or the Norfolk Municipal Airport, with bus, limousine, or taxi available to the Chamberlin.

The Annual Percy Nicholls Award will be presented at the banquet. The recipient is chosen by special Conference committee in recognition of outstanding service to the coal industry through engineering.

A ladies program has been planned to tour many historical points in and around Newport News, Williamsburg, Jamestown, and Yorktown, in addition to the regular events planned for joint participation.

G. G. RITCHIE J. E. TOBEY

On the opening day, Edward E. Williams, ASME, vice president of Duke Power Co. in Charlotte, N. C., will preside at the welcoming luncheon. Mr. Williams is co-chairman of the conference, along with George G. Ritchie, AIME. S. Pemberton Hutchinson is the speaker who will discuss the theme of the conference.

The second luncheon will be presided by Mr. Ritchie and the speaker will be Theodore Baumeister, who will deliver an address relating the impact of Atomic Power Development to the long-term outlook for solid fuels.

ASME National President, James N. Landis will preside at the annual banquet on Thursday evening and C. S. Reid will speak on *Changing Times*.

The luxurious Chamberlin Hotel by the ocean is the headquarters for the conference, October 9 and 10. Old Point Comfort, Virginia, lends an historic setting to this up-to-the-minute discussion of modern day power.

Mr. Ritchie brings to the chairmanship a broad background of experience in the fuel industry. Educated in Scotland and at the University of Virginia, he was selected to organize the Fuel Service Engineering activities for the Coal Traffic Dept. of the Chesapeake & Ohio Railway, where he is now manager. He was a Lt. Colonel in the Army as chief of the Army Fuel Service Unit in the U. S. and abroad. He has been active in coal research projects and is the author of several books and papers on the coal industry.

Other leaders responsible for the conference are the committee and session chairmen. Julian E. Tobey, president, Appalachian Coals Inc., Cincinnati, is chairman of the finance committee. He began his career as a mechanical engineer, and is well known in the industrial power field, having been chief engineer of power plants for 12 years with the Studebaker Corp. He joined Appalachian in 1934 and was elected vice president in 1940. He set up the Fairmont Coal Bureau in New York City and served as consultant in many programs during the war. He has been active in many technical societies, serving as chairman of Coal Div. of AIME, and of Fuels Div. of ASME.

James R. Garvey, program chairman, is director of research for Bituminous Coal Research Inc. in Columbus, Ohio. He was co-designer of the Columbus laboratory and helped establish that branch. His work in the development of coal-burning equipment has placed him in a position of prominence.

J. R. GARVEY

T. S. SPICER

H. B. LAMMERS

C. F. HARDY

The session chairmen pictured here are Theodore S. Spicer, professor of fuels technology, Pennsylvania State College, University Park, Pa.; Herbert B. Lammers, chief engineer, Appalachian Coals Inc., Cincinnati; and Carroll F. Hardy, managing director, Bituminous Coal Inst., Washington, D. C.

Program Changes

The technical program published in the July issue, page 802, is correct except for some final changes in papers to be presented. The fourth paper of the Friday morning session has been changed to *Correlation of Free Swelling Index of Bituminous Coals with other Standard Tests*. H. J. Rose will be the speaker as previously announced.

The final paper of the Friday afternoon session will be *Low Coke Button Bituminous Anthracite Equipment*. The fourth paper on low set-high set spreader stokers is no longer scheduled. The technical sessions will be held in the Roof Garden of the Chamberlin.

ECPD Will Meet in Fall

The 26th annual meeting of Engineers' Council for Professional Development will be held Thursday and Friday, Oct. 9 and 10, 1958, in the Sheraton-Jefferson Hotel, St. Louis.

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Manuscript Deadlines Close for AIME Annual Meeting, February 1959

San Francisco will be the site of the AIME Annual Meeting next February 15 to 19, and SME's headquarters the Sheraton-Plaza Hotel. The hotels have been chosen to accommodate the respective groups and a reservation form is being prepared for late fall mailing by the Institute.

Deadlines for manuscripts are at hand, for papers must be received by program chairmen by September 25 in order to be submitted to the SME Secretary by October 1. These early dates will permit preprinting and possible publication in AIME Transactions which have proved valuable for past conventions.

The completed manuscript may be sent directly to John C. Fox at Society Headquarters. He will need three copies, complete, and ready for reproduction. Drawings should be in India ink, preferably on heavy white paper. Lettering should be large and clear so it will be readable when reduced. Photographs should be black and white glossy prints, preferably all the same size.

Authors must be sure to appropriately identify their papers by topic and division in the transmittal letter, and to clearly state how names should appear on the program, along with titles and business affiliations.

The presentation itself will take about 20 min, though the paper for publication can be longer. A discussion period of 10 to 20 min will follow each presentation, and it may be wise to plant a pertinent question in the audience to begin the discussion. Slide facilities will also be available if authors will specify the type of projector required.

The Divisions have organized their programs and are planning the sessions carefully as papers are received. The Coal Division will have three sessions with floor discussion preplanned for maximum coverage. Special consideration to the western states will be given in response to their large representation.

The Industrial Minerals program includes seven sessions to discuss problems and solutions, new developments, and advanced thinking in the field. There will also be joint sessions with SEG to cover interrelated topics.

The Mining and Exploration Div. will present topics of general interest, with a liberal sprinkling of joint sessions, to cover all fields of mining, geology, and geophysics, with a special symposium on exploration.

The Mineral Beneficiation Div. program plans are "still under wraps" but from reports filtering through, the Division is hard at work on a program dedicated to enhancing MBD's prestige—"by putting on another significant, well-balanced and comprehensive program." Wayne L. Dowdey, as program committee chairman, is busy coordinating the wishes of Division members and lining up papers and sessions.

On the lighter side of the program, a host of social events is being considered. On Monday there will be the welcoming luncheon, a stag dinner-smoker, and an all-Institute cocktail party. On Tuesday there are the all-Institute session and AIME annual business meeting. That evening the Society of Mining Engineers will hold their dinner. A grand banquet for all of AIME will be celebrated Wednesday evening, and Division luncheons and business meetings will wind up the conference.

Drilling and Blasting Symposium Planned For Minneapolis, Oct. 2-4

The Eighth Annual Drilling and Blasting Symposium will be held at the University of Minnesota, Minneapolis, from Oct. 2 to 4, 1958, sponsored jointly by the Colorado School of Mines, Pennsylvania State University, and the University of Minnesota.

The main topics to be considered are recent developments in drilling and blasting practices; problems associated with the use of drilling rods; and drilling and blasting research.

For details of papers to be given, and for registration information, write to the Center for Continuation Study, University of Minnesota, Minneapolis 14, Minn. Fred E. Berger is the director of the Center and would appreciate your prompt response.

This is the first joint symposium to be held by the three universities under the sponsorship program announced recently (MINING ENGINEERING, May, p. 619).

1960 Geology Congress Will Meet in Denmark

Geologists, geographers, mining engineers, and all those interested in the study or practice of geology are invited to attend the 21st International Geological Congress in Copenhagen, Aug. 15 to 25, 1960. Plans are being made for papers, excursions, and general accommodations, under the leadership of Arne Noe-Nygaard, president, and Theodor Sorgenfrei, general secretary.

The First Circular of information has been distributed and response is expected before October 1 from all who wish to attend. Authors should restrict themselves to papers of general interest and should contact the secretary for rules of presentation and deadlines for abstracts. For application forms, write to: General Secretary, Organizing Committee, Mineralogisk Museum, Oster Voldgade 7, Copenhagen K, Denmark.

Final Plans Now Formed For Mid-America Group

Attention again is centered upon the Mid-America Minerals Conference to be held in St. Louis, October 23 to 25. Plans are in their final stage and reservations are being accepted at the Chase and Park-Plaza Hotels. For easy reference, see the August issue, page 892A, for the insert to be used for registration and reservations for meeting functions.

All hotel reservations should be made directly with the hotels. For the Chase Hotel, write to 212 N. Kingshighway Blvd., St. Louis 8, Mo., and for the Park Plaza send a reservation to 220 N. Kingshighway, St. Louis 8, Mo. Both these beautiful hotels offer luxurious accommodations, a lovely terrace dining room and swimming pool, and convenience within the heart of the city.

The program of the conference is listed on page 892B of the August issue. The technical sessions include coverage of minerals beneficiation, geology and geophysics, mining, coal, extractive metallurgy, industrial, minerals, and an iron symposium.

A variety of field trips offer a choice of interesting places to observe. For those curious about coal, the Peabody Coal Co., Freeburg, Ill., will demonstrate their mine and barge loading facilities. An all-day trip will cover mining and milling at Indian Creek mine and mill of St. Joseph Lead Co. and the Pea Ridge deep iron shaft site. For those interested in extractive metallurgy, there will be morning tours of Granite City Steel Mill and Dow Chemical Co. magnesium operations. The Missouri Portland Cement Co. will guide conventioneers through their mining and processing plant.

In addition to the technical sessions and informative excursions, a lively program of social events has been planned. The welcoming luncheon and cocktail party offer a pleasant get-acquainted opportunity the first day, and the dinner-dance on Friday climaxes the day in the lovely Khorassan Room of the Chase.

The wives will be entertained during the conference with activities of their own, including a luncheon and fashion show in the Tiara Room of the Park-Plaza. On Saturday there will be a bus tour of the city to cover all the interesting sites that visitors may have missed on tours of their own. The city has a variety of sights to offer, with smart shopping in the afternoon and theater-hopping in the evening. A full conference has been arranged to satisfy the interests of everyone, minerals and metals men and ladies alike.

Featured Speakers At Mid-America Meeting

The Mid-America Minerals Conference will be honored by two distinguished speakers at the fall meeting in St. Louis, October 23 to 25. Augustus B. Kinzel, AIME President in 1958, and Felix E. Wormser, vice president of St. Joseph Lead Co., will present interesting topics as highlights of the program.

Mr. Wormser will speak at the welcoming luncheon on the subject *Economic Conditions in the Metal Industry*. Mr. Wormser retired last year as Assistant Secretary of the Dept. of the Interior and returned to his position at St. Joe. A 1916 graduate of Columbia University's School

F. E. WORMSER

of Engineering, Mr. Wormser received the Egleston Medal in 1956, for "distinguished engineering achievement." He was also awarded the Columbia Alumni Medal in 1953. He has been secretary-treasurer of the Lead Industries Assn. and the Metal Powder Assn.

The featured dinner-dance in the Khorassan Room of the Chase Hotel will be the setting for Dr. Kinzel's talk on *Metals, Missiles, and Men*. Dr. Kinzel is vice president of Union Carbide Corp., which he joined in 1926, the same year he joined AIME.

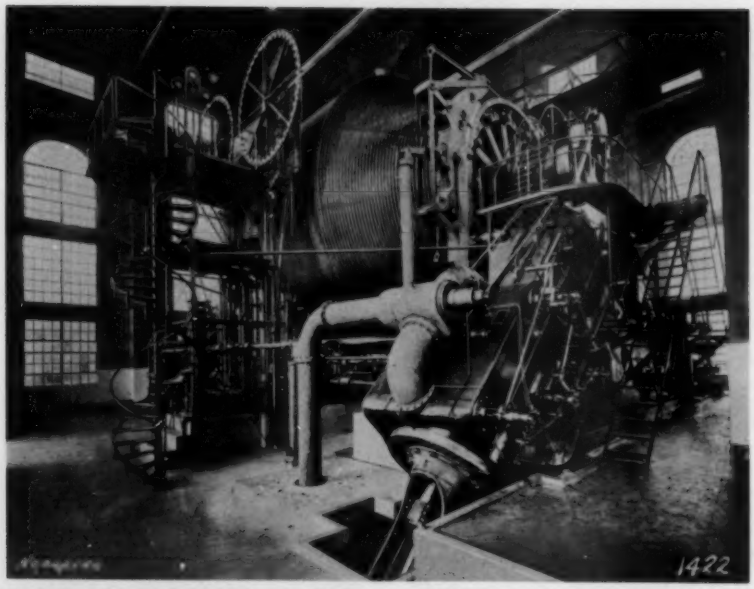
A. B. KINZEL

He is one of the nation's leading research metallurgists, pioneering in ferroalloys, deoxidation, and in pressure vessel design. He is the author of more than 60 technical papers and holds more than 40 patents. During World War II he held key positions on the War Production Board, Economic Warfare Branch, FEA, Minerals and Metals Advisory Board. He has been chairman of the Engineering Foundation Board.

Mile long bridges span the muddy "Ole Man River", a welcome to convention visitors who will attend the Mid-America Minerals Conference in St. Louis at the Chase and Park-Plaza Hotels.

Australasian Institute Plans Sinter Symposium

The Australasian Institute of Mining and Metallurgy, Port Pirie Branch, in recognition of the expanding interest in the sintering process, has planned a Sintering Symposium for September 2 to 6.



The Quincy Mine Hoist, built by the Nordberg Manufacturing Co. in 1921, Hancock, Mich., is the largest hoist ever built in the world and is to be preserved in honor of the mining country of Michigan. This historic site will help tell the story of the mineral industries.

AIME Upper Peninsula Group Joins Historic Quincy Hoist Project

A project to preserve the historical heritage of the iron and copper country of Michigan is being initiated by the Upper Peninsula Section and other local groups with its primary concern the reconditioning and displaying of the Quincy Hoist. This old steam mine hoist at the Quincy Mining Co.'s No. 2 shaft is reputed to be the largest hoisting engine in the world. The Nordberg Mfg. Co. built the machine in 1921 and although it is now inactive, arrangements are being made to keep the hoist intact and the area suitably set up for visiting tourists and mining students.

The Quincy Mining Co. has agreed to join in the efforts of AIME and others to launch this Quincy Mine Hoist Project. W. Parsons Todd, president of the company, has had many valuable suggestions. Other groups which will support the endeavor are the Michigan College of Mining & Technology, the Nordberg Manufacturing Co., and the Keweenaw Historical Soc. The proposed corporation will have nine directors, selected by each of the groups to serve for three-year terms. For the AIME Section, a seven-man advisory board will work with the two directors. Financial assistance will be solicited from the membership-at-large as well as companies and societies. The Nordberg Mfg. Co. has already indicated an interest in the restoration of the hoist itself, a great contribution to the project.

The hoist has a maximum capacity of 13,300 ft of 1⅝-in. rope reaching to a vertical depth of 8600 ft and the time for one trip of 10,000 ft is 4 min, 8 sec.

The purpose of the newly formed corporation is to preserve, commemorate, and do honor to the scientific, engineering and industrial achievements of the mining industry of Michigan's Upper Peninsula. In addition to the historic hoist, other machinery and equipment may be displayed to tell the story of the mineral industries.

Members of the Upper Peninsula group have voted approval for Section participation in the proposed Quincy Hoist Project and their representatives are now working with the other groups on the project.

Vocational, Education Report by Coal Group

The Vocational Training and Education Committee of the National Coal Assn. presented a report at the June convention in Chicago which touched upon crucial problems in education today. Henry C. Woods, committee chairman, explained the purpose of the liaison between the coal industry and the colleges and offered suggestions for improvement in the general post-Sputnik situation.

The committee was formed ten years ago and has visited two universities a year to discuss ideas for advanced curricula, wider job placement and summer employment, better teacher training, and many concrete plans for aid from Government and industry.

Originally the most immediate need was for scholarship programs to enable deserving students to get engineering training. Now the rate of scholarships is growing and a more pressing need for increased salaries and better trained teachers has developed. Mr. Woods suggests that Federal tax laws could be amended to encourage industry to support higher education. Then the Government could concentrate on grants for salary increases commensurate with industry wages.

The committee discovered the neglected area of inadequate preparation for engineering programs and suggested more intensive high school training in mathematics, science, and English. There is a need for counseling to give youngsters the incentive to enter mining engineering. Industry should visit high schools and colleges to urge them to provide necessary training, and to work with them to insure the future of the coal industry.

New Mexico Geologists To Explore Black Mesa

The Ninth Annual Field Conference of the New Mexico Geological Soc. will explore the Black Mesa Basin of northeastern Arizona on October 16 through 18. The conference will deal with the general geology, stratigraphy, structure, economic geology, and water resources of the area.

For further information on the conference, contact Richard D. Holt, Field Conference General Chairman, P.O. Box 1116, Roswell, N. M.

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For the classifying of —¼" sands, the CONCENCO® CPC Classifier does the job accurately and at low cost. It operates by hydraulic water only and is without moving parts. It classifies up to 10 or more sizes, one for each cell in the classifier. Action is visible in each cell and water is easily regulated. Maintenance and operating costs are exceptionally low. Send for full information.

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Geologists Will Survey Colorado Paradox Basin

The Rocky Mountain Assn. of Geologists will sponsor its annual field trip on September 18 to 20, touring northwestern Colorado. The field trip chairman is Doug Callier and Bruce Curtis will edit the symposium guidebook which will cover the Pennsylvanian stratigraphy of the Paradox Basin, northwestern and eastern Colorado.

Registration will take place in Glenwood Springs on September 17. Participants in the field trip will provide their own transportation to Glenwood Springs, and bus and car transportation will be provided for the excursion. Registration cost is $27, payable to the Association, and should be sent to Burton C. Dunn, 1150 Petroleum Club Bldg., Denver 2, Colo. Only 185 applications will be accepted, so early registration is advisable.

Mining Research Group To Discuss Explosives

The Fourth Annual Symposium on Mining Research will be held Nov. 13 and 14, 1958, at Rolla, Mo. The University of Missouri School of Mines and Metallurgy is sponsoring the symposium in conjunction with the U. S. Bureau of Mines. The program is concerned chiefly with the subject of ammonium nitrate explosives. Interest in the theory and application of these explosives has become so intense that the conference has been enlarged to cover two and one half days.

Some tentative program subjects are blasting at Promontory Point with AN explosives; Ripple Rock blasted with AN explosives; underground nuclear detonation—Ranier Operation Plumbbob; thermochemistry of high explosives; blast performance of high explosives; water-compatible AN explosives, mathematics of AN explosives problems; solution of AN explosive problems by IBM; AN explosives research at Missouri School of Mines; field results with AN explosives; experimentation in rock fracture; strain pulses in rock from high explosives; and application of statistical mathematics to explosives research. A final program will be mailed about a month before the date of the symposium.

AIME OFFICERS:

PRESIDENT—AUGUSTUS B. KINZEL
PAST-PRESIDENT—GROVER J. HOLT
PRESIDENT-ELECT—HOWARD C. PYLE
VICE PRESIDENTS—E. C. BABSON, L. E. ELKINS, J. L. GILLSON, J. C. KINNEAR, JR., R. V. PIERCE, A. W. THORNTON
TREASURER—C. R. DODSON
SECRETARY—ERNEST KIRKENDALL

AIME STAFF:

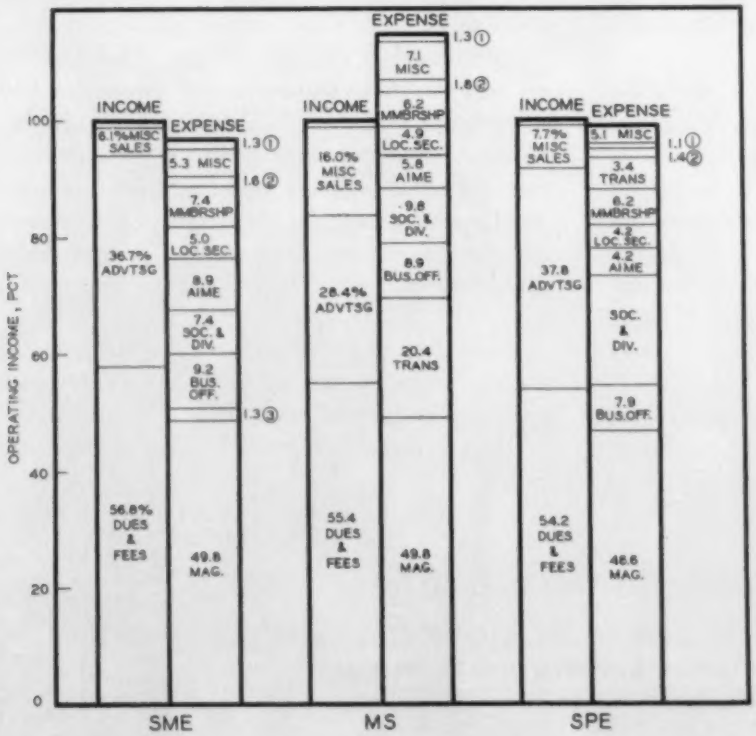
ASS'T. SECRETARIES—J. B. ALFORD, H. N. APPLETON, J. C. FOX, R. W. SHEARMAN
ASS'T. TREASURER—JOHN LYNCH
FIELD SECRETARY & ASS'T SECY.—R. E. O'BRIEN, 707 NEWHOUSE BLDG., SALT LAKE CITY 1, UTAH

AIME NEWS

National Clay Meeting

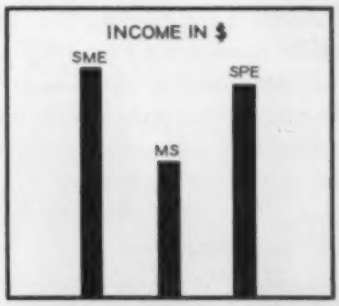
The Seventh National Clay Conference will be held on October 20 to 23, in Washington, D. C., at the U. S. National Museum in the Natural History Building of the Smithsonian Institution. The Clay Minerals Committee of the National Research Council is the sponsor and the chairman will be H. F. McMurdie of the National Bureau of Standards.

SOCIETY OF MINING ENGINEERS OPERATING INCOME AND EXPENSE



How SME Income is Used—

Expressed in terms of Income Dollar Based on 1957 Figures



	INCOME	EXPENSE
SME	$380,000	$369,000
MS *	225,000	260,000
SPE	354,000	351,000

* The Metallurgical Society deficit was made up by appropriations from the Metals Research Publications Fund.

LEGEND

In the chart to the left, circled numbers represent:

1) Library assessment
2) Directory expense
3) Transactions Volume costs

Unmarked space at top of income columns represents miscellaneous income items such as interest.

Nobody Buys a Hole in the Ground

What you pay for is information, and information comes in the form of core—that wonderful petrified record of what the ages have left below the overburden.

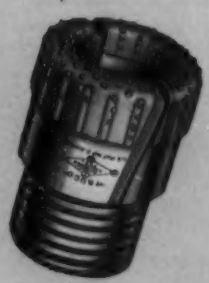
And, when it comes to telling the truth, the whole truth and nothing but the truth, few of the world's records are so perfect and so available as core. Anywhere in the world, drive a coring bit into the earth's crust and nature pours forth her secrets, foot after foot, mile after mile, and—fact after fact. Sometimes the facts may be disconcerting to the theorists but, who can argue with facts preserved in rock and presented in a continuous stretch of core!

Before the diamond coring bit, geologists would piece together the story from chips flushed out with the sludge. Often, it was desperately slow and painfully expensive but was the best way available.

Diamond bits changed all that. Diamond bits not only cut down through tough formations with unbelievable speed and determination but, they did something that never had been done before—they delivered complete cores in which geologists could read the story for thousands of feet without the risk of missing some crucial section which might hold the secret that everybody was looking for.

Nowadays, most drillers know that for fast penetration, longer footage and 100% core recovery, you just can't beat Truco bits.

And Truco bits keep on proving it every day.



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ROCK IN THE BOX

Mining & Exploration Division

Plans are progressing for the 1959 AIME Annual Meeting in San Francisco. The M&E Units are busy arranging a wide range of subjects, with comprehensive joint sessions to answer the wishes of miners, geologists, and geophysicists.

The cooperation between units is epitomized in the exploration symposium which will involve all the groups, while a panel of ten experts discusses the problems of mining exploration. Another joint session will feature case histories of the three earth sciences. Then specific sessions will handle individual interests such as geochemical techniques. In this way the conference program will cover general themes and special concerns.

Jackling Lecture

The Jackling Lecture at the meeting will be presented by R. S. Archibald, president of North Range Mining Co., Negaunee, Mich. Mr. Archibald will also receive the Daniel C. Jackling Award Plaque.

Future Meetings

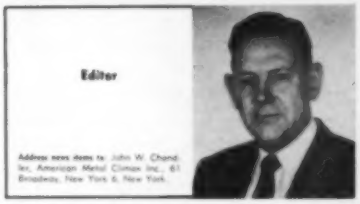
Many other meetings of interest to mining men are being planned for the near future. The eighth annual drilling and blasting symposium will be held at the University of Minnesota, October 2 to 4, sponsored jointly by the Colorado School of Mines, Pennsylvania State University, and the University of Minnesota. Recent developments, problems, and drilling and blasting research will be the main topics of the conference.

In November there will be a symposium on mining research at the University of Missouri, in cooperation with the U. S. Bureau of Mines, to study and discuss ammonium nitrate explosives. Specific blasting projects, fundamental elements in blasting problems, and mathematics, research, and experimentation will all be included in the program.

Field trips have also been scheduled for the fall months to interest the geologists. The Rocky Mountain Assn. of Geologists are touring northwestern Colorado this month. They will explore the Paradox Basin. In October the geologists in New Mexico will explore the Black Mesa Basin of northeastern Arizona. This interesting caravan will tour the Painted Desert, the Hopi Buttes, and wind up at the Grand Canyon.

Academic Standards

A subject of general interest to all engineers and geologists, the standards of academic training, has been reviewed by the Colorado School of Mines and concrete steps have been taken to maintain their high scholastic record. Science education is a complex problem today since the Sputnik scare, and the increase in college age population has made a revision in acceptance standards necessary. The question remains whether it is better to expand the facilities of the college or weed out

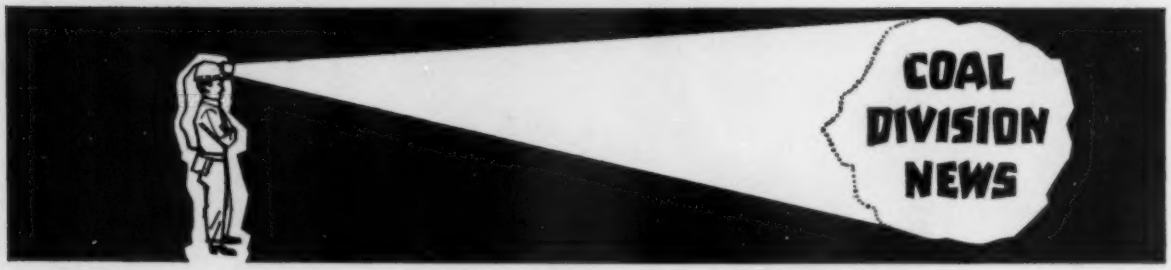


a greater percentage of applicants. Many who would have received a college education a few years ago will be turned away because of the increased competition. The level of academic training will be raised, but the number prevented from going to college will also increase.

The Colorado School of Mines has traditionally held its number of scholastic drop-outs to a minimum by weeding out a substantial percentage with the entrance requirements. Those who have been accepted have earned a high record. Starting in 1960 the school will add the requirement of the Scholastic Aptitude Test of the College Entrance Examination Board in Princeton, N. J. This exam has been given to out-of-state applicants but will be part of general admission requirements in 1960. Many colleges and universities have been using this standard estimate of ability for years, and the Colorado school feels confident that this method of careful selection will help maintain the school's high record.

Mining, Minerals, and Petroleum Men to Convene at Rocky Mountain Conference

Salt Lake City, fringed by the Wasatch Mountains that rise sharply from the flat desert floor, is the site of the Rocky Mountain Minerals Conference, September 17 to 19. Sights for visiting conventioners include the Mormon Tabernacle, whose spires stand regally at right, and the Great Salt Lake. For details of program, speakers, and session topics, see the August issue, page 895.



A great responsibility of Industry leadership is to insure the growth of tomorrow's leaders

The Coal Division is playing a unique role in meeting this responsibility, in that the present industry leaders who are members are making tomorrow's leadership their business.

Perhaps the best witness to this is the statement below by one of these leaders. As he puts it, "AIME is the only individual medium available to each and to all engineers who qualify for membership." He further urges that the Institute and Division rolls be made to resemble a "Who's Who" of the industry.

This business of membership is the responsibility of all who belong to the professional organization. If you believe in the Society—its aims and its purpose, you assume an obligation to see that it continues as a live and growing organization.

How can you contribute? See that your colleagues on all levels of the industry become members and participate in the programs of the organization, as active members, not names on a list.

MINING ENGINEERING is supplying a membership application—pages 1015 and 1016. Tear it out. Tell one of your engineering friends why AIME, SME, and the Coal Division are his professional organizations, too. Help him fill out and mail the application.

United States Steel Corporation

525 William Penn Place

J. C. GRAY
ADMINISTRATIVE VICE PRESIDENT
RAW MATERIALS

Pittsburgh 30, Pa.

July 14, 1958

Dear Members of Coal Division:

We all know that AIME is the only individual engineering medium available to each and to all engineers who qualify for membership.

I am a strong believer in the Institute's value to its members in their professional lives. More specifically, from my own experience as a member, I can recommend that,

a. Men in the more responsible positions in management have much to gain by being associated with their fellow engineers, both young and old. Their interest in other engineers can provide a stimulating uplift to the dignity of the profession. It will also keep them acquainted with the accomplishments and ideas of the younger men.

b. The young engineers need the association with the Institute in many ways. Their effective professional life can be stimulated by feeling that they are a part of the ethics of a professional society. The association with older fellow engineers whose life work has been in the engineering profession, and who are committed to the dignity of such, cannot be measured in money or effort.

Therefore, I can urge strongly that the Institute's membership list should be a complete list of all engineers associated with mining and, in fact, just about a "Who's Who" of the industry.

Sincerely,

J. C. Gray

Administrative Vice President

J. C. Gray/s

James C. Gray, writer of the membership testimonial reproduced here, is administrative vice president — raw materials of U.S. Steel Corp., Pittsburgh. At present he is serving as a member of the Coal Division Executive Committee and has been nominated by the Division to serve a three-year term on the Society of Mining Engineers Board of Directors, beginning in February 1959. A graduate of Pennsylvania State University and native of Eleco, Pa., Mr. Gray became associated with U. S. Steel in 1937 in the Tennessee Coal and Iron Div. He began his career in coal with Hudson Coal Co.

Nomination

The third nominee for the Coal Division Executive Committee in 1959 is R. G. Kazzell, engineer, planning and development, Island Creek Coal Co., Huntington, W. Va.

Future of Nonferrous Mining in British Isles To Be Symposium Topic

The Institution of Mining and Metallurgy is conducting a symposium on the future of nonferrous mining in Great Britain and Ireland on September 23 and 24 in London. The meeting is being arranged in cooperation with the United Kingdom Metal Mining Assn.

A review of the mineralized areas and a discussion of technical and economic problems will aim at an appraisal of the potentialities of the nonferrous mineral industry with the hope of its revival.

Members: Help a Nonmember fill out this handy application—

A Constituent Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers

SOCIETY OF MINING ENGINEERS OF AIME

29 WEST 39TH ST.
NEW YORK 18, N. Y.

APPLICATION FOR MEMBERSHIP IN AIME

FOR OFFICE USE

L.S.	Admissions Committee
Class.	Approved:
Rein.	
C/S	Recommendation:
Card	
Rec.	Elected:
Ack.	Accepted:

Credit application to: _____ (Member's Name)

I hereby apply for { admission / change of status / reinstatement } to the grade of _____ (Member; Associate Member; Junior Member) in the SOCIETY OF MINING ENGINEERS OF AIME

Name (Please print) _____ Last Name _____ First _____ Middle

Company _____

Your Business Address Where Employed _____

Please State Nature of Company's Business: _____

Professional Title _____ Present Position _____

Address where you desire Society mail to be sent (If not your business address) _____

Born (exact date) _____ at _____ Citizen of _____

ENDORSEMENTS . . . Applications must be endorsed by three AIME Members, Associate Members, or Junior Members who know the applicant personally. Endorser should fill in the spaces to the right of his signature. (Membership in certain other technical societies that have equally high standards of membership may be used in lieu of two endorsers if necessary.)
If you wish the Society to secure the necessary signatures, please list the names of four members who are familiar with your profesional qualifications.

(Print here)	Signature	How long have you known the applicant?	Has he been employed under your supervision?	Grade for which you believe him qualified
Name _____				
Company _____				
Name _____				
Company _____				
Name _____				
Company _____				
Name _____				
Company _____				

EDUCATION Give specific degrees and exact dates. A technical education is not requisite for membership.

	Dates	Degree and Date	Major Subject Or Engineering Field	Minor Subject
Preparatory School _____				
Technical School or College _____				
Graduate Work _____				

If you attended college but did not complete, indicate course taken and number of years completed _____

Be Sure to Fill in Both Sides—Turn the Page

PRIMARY INTEREST FIELDS Please indicate the technical fields in which you are most interested. Mark 1, 2, and 3 in order of preference.

- ☐ Open Pit Mining (Ore)
- ☐ Underground Mining (Ore)
- ☐ Geology
- ☐ Geophysics
- ☐ Geochemistry
- ☐ Coal
  - ☐ Mining
  - ☐ Preparation
  - ☐ Utilization
- ☐ Industrial Minerals
- ☐ Minerals Beneficiation
- ☐ Education
- ☐ Economics

RECORD OF EXPERIENCE

Please list in chronological order a complete record of your employment. Be explicit as to dates, your duties, nature of the work, and the extent to which you were in responsible charge of your own work or of the work of others. Include all positions held, whether or not they are related to the mineral industry. If additional space is needed, use separate sheet of the same size.

Dates From	To	Title of Position, Name of Company Description of your work	Total Time	Time you were in responsible charge*	Name, Title and address of your immediate superior, or of other person familiar with your work

I agree, if elected, to accept election, pay the necessary fees, and to abide by the Constitution and Bylaws.

Do you desire to pay the Entrance Fee in four installments of $5.00 each

Yes _____ No _____

_____
Signature

Date _____

*Responsible for the conduct of technical or engineering work. Employment as a teacher may be so considered responsible for conduct of work.

Around the Sections

• The **Washington, D. C., Section** had their annual field trip on June 3, visiting the Baltimore Harbor Tunnel and the Davison Chemical Co., Baltimore. A short talk on the design and sinking of the tunnel and on the ventilation system was included, as was a tour of the tunnel fan house. At the Davison plant, a subsidiary of W. R. Grace & Co., the petroleum catalyst production was studied as well as the phosphate rock plant. Luncheon was served at Davison.

• The annual spring technical session of the **Upper Peninsula Section** was chiefly concerned with the preservation of the Quincy Hoist, and a tour of the world's largest hoisting engine had been arranged. For further details of this historic engine, see page 1010. Two papers were presented at the meeting by seniors at Michigan School of Mining & Technology entitled *Dust Controls and Effect in the Materials Handling System at White Pine* by Mike Trainer and *Rock Fragmentation by Dielectic Heating*, by Donald McCain and Kenneth Nelson. The ladies were provided with an exhibit of copper jewelry and a talk by Roy Drier on *Extrasensory Perception*. A coffee break, social hour, and annual luncheon completed the program.

• The Pittsburgh Section, **Mineral Industry Group,** held an all-day field trip on May 2 to the Shippingport Atomic Power Station and the Josephtown Smelter of St. Joseph Lead Co. Guides from the Duquesne Light Co. described the atomic plant in detail with the aid of display models. Members viewed the canal area above the reactor, control area, turbine-generator area, waste disposal set-up, and certain laboratory and health facilities. After lunch provided by the women's auxiliary of the Shippingport Volunteer Fire Dept., the members traveled to the Josephtown Smelter to observe the integrated zinc smelting operations in which zinc sulfide concentrates are roasted, the sulfur dioxide gases are converted to sulfuric acid, the roaster calcines are sintered, and sinter is reduced to zinc metal.

• Walter R. Hibbard, Jr., President of The Metallurgical Society of AIME, was the guest of honor at the May 8 meeting of the **Utah Section** at the Newhouse Hotel, Salt Lake City. Speaking on the topic *Alloy Developments in the Missile Age*, Dr. Hibbard, who is associated with General Electric Co., alluded to some of the Russian technical advances in this field. He was one of a group of American scientists who visited Russia last summer.

• The newly established **Wyoming Mining and Minerals Section** has announced its list of officers. The chairman is Joseph W. Joyce of Western Nuclear Corp. First vice chairman is Elton Clark and second vice chairman is Robert Ford. John Atkins has been chosen as secretary-treasurer. The directors and members of the executive committee are: John Anderson, Thomas Bernatis, I. M. Charles, H. G. Fisk, and Roy L. Wahl. Robert Ford is also membership chairman and Elton Clark also serves as program chairman.

• The **Lehigh Valley Section** held its annual inspection trip on June 20 at 7:30, visiting Neuweiler's Brewery in Allentown, Pa. Details of operation and processing were explained, and refreshments were served, compliments of the brewery.

• The **Philadelphia Section** sponsored a "U. S. Steel Night" in May with a dinner at the Hotel Hildebrecht. Featured speakers were Royce D. Northcutt and Eugene L. Bartolotta. Topics under discussion were iron and steelmaking in the Delaware Valley, sulfur removal, and mechanized coal mining.

• The **Oregon Section** June meeting was held in the Burns Restaurant, Portland, with a social hour and dinner preceding the meeting. The speaker was Leslie C. Richards who discussed *The Colorado Oil Shale Operation*.

• The **Pennsylvania Anthracite Section** annual summer meeting took place at Split Rock Lodge, White Haven, Pa., on Lake Harmony in the Poconos. This meeting was restricted to members and their ladies. Guests of honor were the President of AIME, Augustus B. Kinzel, and Mrs. Kinzel, Secretary Ernest Kirkendall, and the secretary of the Pennsylvania Dept. of Mines, Joseph T. Kennedy. President Kinzel spoke.

New officers have been elected to serve this coming year. The chairman of the Section will be Harold B. Wickey of The Glen Alden Corp. Vice chairman is John S. Marshall and the new secretary-treasurer will be Floyd S. Sanders. The following men were elected to the executive committee for three-year terms: John C. MacCartney; Charles E. Brown; Daniel M. Blackburn; D. E. Ingersoll; and James J. Tedesco.

• Announcements in verse proclaimed the summer picnic of the **Knoxville Area Subsection** of the Southeast Section on August 2. Swimming and boating, good food, and cold drinks enticed AIME families to join the fun at Harrison's farm on Fort Loudon Lake.

At a luncheon on May 15 at the Sherwyn Hotel, C. Law McCabe, outgoing chairman of the Pittsburgh Section, turned over to Jack Vonfeld the duties of chairman and presented him with the gavel, symbol of office. At the left is J. M. Henderson, incoming vice chairman, and G. E. Keller, member of the executive committee and SME Coal Division Secretary, is on the right. Other new Section officers are R. S. Crowell, secretary, and J. H. Melvin, treasurer.

Personals

At the Honors Convocation of Michigan College of Mining and Technology in May, two honorary master of engineering degrees went to **Ronald C. Seeley,** manager of the Washington, D. C., regional office of Merritt-Chapman and Scott Corp., and **Rupert M. Foley,** sales engineer in the FluoSolids Div. of Dorr-Oliver Inc. **George W. Cannon,** founding partner of Campbell, Wyant and Cannon Foundry Co., Muskegon, Mich., gave the main address and was awarded the honorary doctor of engineering degree.

The Colorado School of Mines awarded doctorates in May to the following engineers: **Lawrence Ogden,** geological engineering; **Robert S. Hufstedler,** petroleum-refining engineering; **Arthur W. Ruff,** mining engineering; and **Mohammed N. Qureshy,** geophysical engineering.

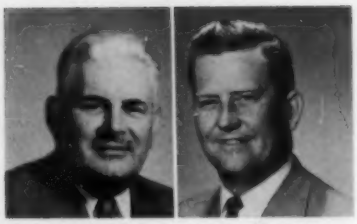
The Montana School of Mines commencement exercises in June saw the presentation of professional degrees to **James J. Dougherty, Chris G. Dobson,** and **Charles C. Goddard, Jr.,** all former students and now assistant superintendent, Anaconda Reduction Works; principal engineer, U. S. Treasury Dept.; and geologist-in-charge, Butte Mines, The Anaconda Co., respectively.

A. Vernon Sproles, formerly vice president in charge of operations, has been elected president of Pocahontas Fuel Co., Div. of Consolidation Coal Co.

R. H. Channing, president and director of the Hudson Bay Mining and Smelting Co. Ltd., retired last year. He had been with the company since its inception.

John C. Hagen, geologist for the Ozark Ore Co. in Missouri, has been transferred by The M. A. Hanna Co. to St. John d'el Rey Mining Co., where he will investigate the gold and iron ore resources of the company in Brazil.

A. C. Borgeson, Chisholm, Minn., retired as chief mining engineer of The Shenango Furnace Co., and



E. N. KUNKLE R. W. REEDY

Snyder Mining Co. after 47 years of continuous service.

Earl N. Kunkle has been elected vice president in charge of the cement plant division of Kennedy Van Saun Manufacturing & Engineering Co. He has been affiliated with the company since 1930, serving in the sales field and production department.

Richard W. Reedy has been elected assistant vice president of Kennedy Van Saun Manufacturing & Engineering Corp. He has been assistant to the president.

E. R. Gordon is now assistant manager, Mineracao Hannaco Ltda. He had been director, Exploration Div., Grand Junction Operations, U. S. Atomic Energy Commission.

Joel N. Cooksey, Jr., formerly mining engineer for the Peabody Coal Co., is now a second lieutenant in the United States Army.

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

.....

Address

.....

.....

.....

Name of AIME Member:

.....

Address

.....

.....

.....

CHANGE OF ADDRESS AND PERSONALS FORM

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

Name .....

Old Address .....

.....

.....

New Address .....

.....

.....

PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company .....

Former Title ..... Length of Time There .....

New Company .....

New Title ..... Date of Change .....

.....

Any recent activity that would be of interest to members:

.....

.....

.....

Bahngrell W. Brown, who was acting head of the Dept. of Geology, Montana School of Mines, now is an associate professor at Mississippi Southern, Hattiesburg, Miss.

J. L. Weddle, sales engineer for Western Machinery Co., is now in business for himself in consulting engineering in geology, mining, and metallurgy. He can be reached at his home in Upper Montclair, N. J.

Gustavo Camposano, who was mill superintendent for Mining Enterprises Corp., now is a metallurgical engineer for Frontino Gold Mines Ltd., Colombia. Another new member of this firm, which is owned and operated by Colamer Inc., is **William Bourne Wood,** formerly a research metallurgist for Consolidated Copper Mines Corp. He is now chief chemist as well as research metallurgist.

K. H. McMahon is assistant to the managing director of the Commonwealth Mining Investments (Aust.) Ltd., Sydney, Australia. He had been mine manager of the New England Antimony Mines and had worked in British Columbia and the western U. S.

Lew Adamec, formerly assistant general superintendent, Benguet Consolidated Inc., is now general manager, Cia. Minera Peralta, S.A. de C.V., Chihuahua, Mexico.

J. P. KENDRICK W. C. HUTCHINSON, JR.

James P. Kendrick, formerly sales engineer for Mine Safety Appliances Co., Pittsburgh, in Lima, Peru, has been transferred to a similar position with the firm's subsidiary in Mexico City, Mexico. He has been succeeded in Lima by **William C. Hutchinson, Jr.,** who joined the firm last year.

C. A. Mason, who was diamond drill foreman for Andes Copper Mining Co., Chile, is now field supervisor for Canadian Longyear Co. Ltd., North Bay, Ont., Canada.

A. J. Oppermann has completed a tax map project in West Chester for Chester County Commissioners and has transferred to Cabell County, W. Va., to supervise property mapping there. He is employed by the Aero Service Corp. and is based in Huntington, W. Va.

Robert P. Koenig, president of Cerro De Pasco Corp., delivered the address at the 58th commencement, Montana School of Mines, and was awarded the degree of doctor of engineering, honoris causa.

Howard G. Schoenike, consulting mining geologist of Houston, presented an illustrated talk on *Some Interesting Mineral Deposits and Possibilities in the Southern U. S., Mexico, and the Caribbean Regions,* at the meeting of the Houston Geological Soc. on May 12.

Herbert E. Hawkes, Jr., who joined the faculty of the University of California last September, is now professor of mineral exploration.

G. E. apRoberts has resigned his position as manager of the Mining Div. of the Cate Equipment Co., Salt Lake City, to accept the position of vice president and general manager of the Utah Salt Co. Inc., Salt Lake City.

Raymond K. Robbins, assistant geologist for the Tennessee Coal and Iron Div., U. S. Steel Corp., is now geologist for the Texas Petroleum Co., Peruvian Div., Lima, Peru.

John R. Van Pelt, president of Michigan College of Mining and Technology, gave the commencement address at the Kingsford High School in Michigan.

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personals

continued

Eiichi Nomura, chief of the planning board of the Nippon Mining Co. Ltd., Tokyo, Japan, is now gerente general at the Sociedad Minera Andromeda Ltda., a small copper mine and plant near Antofagasta, Chile, which his firm bought and put into operation in March.

S. J. Dickenson, secretary-treasurer of the Mary Helen Coal Corp., has been re-elected by bituminous coal producers as a director of the National Coal Assn. to represent eastern Kentucky. **Charles A. Hamill** and **J. R. Maust** have been re-elected as members of the board of directors. Other re-elections include **Ralph H. Moore,** vice president of the Rich Hill Coal Mining Corp.; **R. T. Todhunter, Jr.,** vice president of Barnes & Tucker Co.; and **J. S. Besser,** vice president in charge of fuel sales for Colorado Fuel & Iron Corp. Newly elected to the board is **William M. Osborne,** president of Youghiogheny & Ohio Coal Co., and **Wilfred S. Webster** vice president and general manager, Walter Bledsoe & Co.

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Edward Matson has been transferred from the St. Anthony Uranium Mine in New Mexico to the Golden office of American Metal Climax Inc., where he will help plan development of the company's uranium properties in Texas.

Edwin C. Sponberg, superintendent of the Scranton iron mine, Mesabi range, has retired, rounding out 33 years with Pickands Mather & Co.

The Colorado School of Mines silver anniversary class of '33 honored six Mines faculty members who have devoted their lives to teaching. **Robert A. Baxter,** professor of chemistry, who has been at the school since 1922, was among the men honored at the dinner.

Henry J. Petrie has been appointed mining and ore dressing sales engineer for the Vitro Engineering Co. in the expansion and reorganization of the sales staff.

W. C. LYTLE

J. F. THOMPSON

William C. Lytle has been elected a vice president of the Atlas Powder Co. in charge of the Explosives Div. He had been assistant to the senior vice president.

John F. Thompson, chairman of the board of The International Nickel Co. of Çanada Ltd., has been awarded the Gold Medal of The Institution of Mining and Metallurgy, London, for 1957 "in recognition of his distinguished services to metallurgical science, research and practice, with special reference to the nickel industry."

Glynn L. Coryell is the new head of the engineering department of the National Coal Assn., having been an engineering consultant on the staff for five years. He succeeds **C. A. Reed,** who has retired after 22 years as head of the department that he established. Mr. Reed is now employed by the Spanish government to develop a program for use of Spanish and American coal.

Lee Bilheimer was formerly a mining engineer with the Newmont Exploration Ltd. and is now mine research engineer for St. Joseph Lead Co. in Farmington, Mo.

Earl E. W. Kearly, who was production engineer for the Consolidated Coppermines in Kimberly, Nev., now is senior mine engineer for the Utah Mining Corp. in the Gas Hills District at Lucky Mc Uranium Mine.

R. E. SCHNEIDER

R. F. GRIFFITH

Ralph E. Schneider, formerly assistant secretary and assistant treasurer of The Anaconda Co., New York, is now secretary and treasurer, succeeding **Earle Moran** who has retired.

Robert F. Griffith just returned from French Guiana, where he had been examining and evaluating gold-tantalite placer deposits. He now is manager of the Timber and Minerals Div., J. M. Huber Corp., St. Albans, W. Va. Formerly he had been manager, Marine Minerals Div., Heavy Minerals Co.

A. M. Thomas, mine foreman for Mineracao Wah Chang, S. A., has been transferred from the south division to the north division in Brazil.

James J. Scardino is geologist for the State of Idaho Dept. of Highways. Before this appointment he had been mine geologist with Wah Chang Mining Corp.

David P. King has just completed his two-year military service and has returned to the Atomic Energy Commission as a geological engineer. He is working out of the Casper Branch Office in the Rawlins Area Office in Wyoming.

W. O. Brandt, formerly manager, Technical Services, Pacific N.W. Div. of Gladding McBean & Co., has been made director of research for the Denver Fire Clay Co., Denver. The firm is building a large new research laboratory in connection with expansion of the company's ceramic and refractory business.

Nathan M. Levine, formerly senior research metallurgist for Howe Sound Co., who received a doctorate from Columbia in 1956, now is in product development for the Stein Hall & Co. Inc.

Charles G. Quigley, former superintendent of the Utah Arthur Mill, Kennecott Copper Corp., has been appointed head of the newly created Dept. of Quality Control. Succeeding him as superintendent is **Wayne H. Burt,** former operations office engineer at Kennecott's New York offices.

George T. Miller, who was a student at the Missouri School of Mines, is a mining engineer for the U. S. Gypsum Co.

George H. Schenck recently became associated with Azbe Corp. as project engineer in St. Louis, Mont. He received a master's degree from

Carnegie Institute of Technology while working as a development engineer for Crucible Steel Co.

James C. Schenk graduated in January from the Mackay School of Mines, University of Nevada, and is now an assistant mine foreman for Cerro de Pasco Corp. in Peru.

Jack J. Burke was recently transferred from the western to the eastern district of Gardner-Denver Co. to be sales manager for Compressor and Rock Service Corp., the rental and sales organization, mining and construction, for the company.

Karl H. Renner, formerly mining engineer with U. S. Gypsum Co., is highway survey and construction engineer for Michigan State Highway Dept., Lansing, Mich.

C. S. Sharp, gravity-magnetic party chief for the Hunt International Petroleum Co., has been conducting gravity and magnetic surveys over some of the Libyan Desert.

Donald F. Campbell, who had been exploration project manager for Kaiser Exploration Co., has been made manager of the Brazilian Branch of Geoprosco Ltd., London, with headquarters in Rio de Janeiro.

Walter Guggenheimer is working as mine foreman for Cerro de Pasco Corp., Morococha Div. in Peru. He

A. L. FAIRLEY, JR. F. A. WARDLAW, JR.

had been working as a designer for F. C. Torkelson Engineers while studying at the University of Utah.

Albert L. Fairley, Jr., widely known U. S. industrialist, has been appointed executive vice president and director of Canada's Dominion Steel and Coal Corp. Mr. Fairley is vice president and director of the Shenango Furnace Co., the Lucerne Coke Co., and the Snyder Mining Co., all of Pittsburgh, and will also serve as executive vice president of the Nova Scotia Steel and Coal Co. Ltd. and the Dominion Coal Co. Ltd., Dosco subsidiaries.

Frank A. Wardlaw, Jr., has been named resident consulting engineer and sales representative in the Rocky Mountain area for the Engineering and Construction Div. of Southwestern Engineering Co. Before his retirement, Mr. Wardlaw had been with The Anaconda Co. for more than 34 years, serving as general manager of mines and smelter operations in the Intermountain Area of the western U. S. He is a past-president of the Utah Mining Assn.

Dudley L. Davis is now managing director of Kumhila Exploration Ltd. at Vancouver, and will be in charge of the company's dredging operation at Wells during the summer. He was appointed managing director of the Gil-Rand Mining Stock Co. in Reno, Nev., where he is also general manager of Bay Shore Mining Co. Inc. with permanent headquarters in Salt Lake City.

D. L. DAVIS

C. B. TILLSON, JR.

Charles B. Tillson, Jr., former general superintendent of Crucible Steel Co. of America mines, has been named assistant manager of the company's fuel division. He will exercise general supervision over the coal mines at Crucible, Pa., and Hugheston, W. Va.

William L. Crentz, U. S. Bureau of Mines chemical engineer at Washington, D. C., received an award from the Bureau in recognition of his role in organizing and obtaining American participation in the Third International Coal Preparation Congress at Liege, Belgium, June 23 to 29. As the only American on the organizing committee, Mr. Crentz was responsible for inviting and reviewing papers by American experts. He also was chosen to preside at the United States session of the meeting.

Felix du Breuil, a native of Paris and a former engineer in the mining research and development department of the Jeffrey Manufacturing Co., has been appointed project engineer for Bituminous Coal Research Inc. Dr. du Breuil has been assigned to a coal plasticity project at the Columbus, Ohio, laboratory.

James H. Keener has taken over the management of the South Suburban Water Co. in addition to the Stratton Cripple Creek Mining & Development Co. that he had been managing, and has moved the mining offices to Colorado Springs, Colo.

John V. A. Sharp received a Pan-American Oil Co. fellowship to work for a Ph.D. No longer field geologist for Southern Pacific Co., he is now in the Dept. of Geology at Colorado University, Boulder.

Walter C. Spence, formerly research engineer for Shawano Development Corp., is now project engineer at the Colorado School of Mines Research Foundation Inc., Golden.

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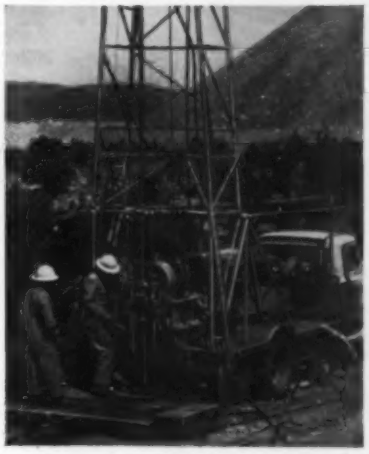

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Obituaries

Franklin Albee Flodin

An Appreciation By
The Iron Mountain News

F. A. Flodin (Member 1957) president of Lake Shore Inc., who died recently at his summer home at Spread Eagle, Wis., has left his two home communities—Marquette and Iron Mountain—a rich legacy of community service and progress.

Mr. Flodin will be remembered by his family and associates as a man who, early in his business career, decided where he was going, and then proceeded to go there by the only method he knew and exemplified—hard work, self-discipline, and the application of sound business methods.

To his fellow townsmen in Marquette and Iron Mountain, Mr. Flodin will be long remembered as a man who contributed generously of his time, money, talent, and effort to the development of the community. He was, above all, a loyal *home-towner*, and lived and worked according to that theme. He achieved this reputation in various ways, but generally by the direct approach of setting the goal and driving towards it with every means and facility at his command.

Today, Lake Shore Inc., reaching out into various fields of industrial activity, stands as a solid and impressive monument to his drive and energy. Mr. Flodin knew, many years ago, what he wanted for Lake Shore, and he missed few opportunities to extend the influence and prestige of the company. Thus, Marquette and Iron Mountain have consistently enjoyed the byproduct of his organizing genius through operations and payrolls that have weathered the economic storms and gone on to better things.

Mr. Flodin's busy schedule by no means kept him from his family and friends. If he had an outstanding hobby, it was mainly to gather his family about him and travel to some distant land—to expand his horizons. He sought the new and different, but he also liked small, friendly gatherings and spirited talk.

Mr. Flodin made no secret of his goals in life. They were to be happy in his home, to be personally successful in business, and to expand the influence and impact of Lake Shore Inc. into new and ever-modern fields of operation.

It may be said, here and now, that Mr. Flodin not only reached these objectives, but was moving steadily towards new goals when he was stricken ill.

This community owes Mr. Flodin a solid debt of gratitude for his many-sided contributions to its progress.

Mr. Flodin was born Jan. 14, 1903, at Marquette where he attended public schools and graduated in June 1921, from the Culver Military Academy.

From the spring of 1922 to 1924, he was employed in the office of the late N. G. DeHaas, materials broker at Marquette, starting as a filing clerk and advancing to salesman. When he was 21, he came to Iron Mountain as an employe of the Service and Supply Co. He became a partner in the company and in 1929 the proprietors gained a controlling interest in the Lake Shore Engine Works. In 1938 the Lake Shore Engineering Co. was formed by the merger of the two companies, with Mr. Flodin as president. Later, the company name was changed to Lake Shore Inc.

Mr. Flodin was an associate of the National Industrial Conference Board; member of the Industrial Conference of the College of Engineers, University of Michigan; and recently he was appointed by Governor G. Mennen Williams as Michigan industrial goodwill ambassador.

Charles T. duRell (Legion of Honor Member 1903) died Feb. 28, 1958, in Pomona, Calif. He had retired from engineering in 1937 after a long and varied career. Born in Vermont, Ill., he received a degree from the Colorado School of Mines in 1895 and began as assistant to the superintendent of the Mt. Wilson Gold and Silver Mining Co. near Telluride, Colo. He was a member of the firm Limbach & duRell in Cripple Creek doing general surveying and valuations, then worked in South Africa, constructing plants. From 1902 to 1905 he was manager of several mining companies coincidentally while doing consulting work for Homestake Gold Mining Co. In 1907 he was superintendent of the Death Valley Gold Mining Co. and of the Arcalvada Mining Co., shipping silver ore to Salt Lake smelters. He began investigating natural resources in the Philippines and became manager of the Headwaters Mining Co. there in 1910. He toured Australia, studying engineering and mining projects, and did research work at the Colorado School of Mines. He was a consulting engineer for several firms in California and was a captain, engineers, in the U. S. Army in 1918. From 1920 to 1936 he worked as senior valuation engineer for the Bureau of Internal Revenue where he had charge of the depreciation study and publication. After retirement, Mr. duRell did consulting work in California.

John E. Hammell (Member 1933), Canadian mining executive, died in Oakville, Ont., on May 8, 1958. He was born in Beeton, Ont., in 1876 and was a pioneer in the north country for 25 years, responsible for creating the Porcupine Crown Mines and the Flin-Flon Copper & Zinc Mines in Manitoba. He was one of the first pioneers of the Rouyn district of Quebec, where he installed the first two diamond drills in that field. He also found the first silver outside of Cobalt Camp in the Montreal River district. Mr. Hammel was president and managing director of several companies including Val d'Or Mineral Holdings Ltd.; Pickle Crow Gold Mines Ltd.; and Staratt Olsen Gold Mines Ltd.

Birdell J. Roberts (Member 1916), sales manager for the Deister Machine Co., Fort Wayne, Ind., died on May 24, 1958. He was born and raised on a farm near Roanoke, Ind. For 11 years he worked for the Pennsylvania Railroad before going to Mexico with the Deister Miners Supply Co. in 1911. For three years he was research engineer and superintendent of mills for Embree Iron Co. in Tennessee and he worked in Kentucky supervising construction work for two other firms before joining his friend Emil Deister in 1925, in the position he held at the time of his death, 23 years later. His work in the preparation and concentration, cleaning and screening of ores, coal, and aggregates took him all over the U. S. and into Canada and Mexico. He continued his active field work until his final year.

Robert Wallace (Member 1917) died recently at his home in Dedham, Mass. He had been manager of the

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Midvale smelter, U. S. Smelting, Refining & Mining Co. until his retirement. Mr. Wallace was born in 1884 and graduated from Harvard University in 1905. He started work in the engineering department of the Cleveland-Cliffs Iron Co. in Michigan, then spent a few years in Mexico, where he advanced to mine superintendent at the Angangueo unit of American Smelting and Refining Co. He returned to the U. S. in 1909 and worked in Tennessee and Montana surveying, and as a metallurgist in Utah. In Bingham he witnessed the first application of flotation to concentrate lead ores in the state. In 1916 he joined U. S. Smelting where he advanced from general roaster foreman to superintendent and finally manager in 1939.

Michael P. Walle (Member 1951) died May 22, 1958, in Duluth. He had been chief research engineer for the State Dept. of Lands and Minerals. Mr. Walle was born in Herstal, Belgium, in 1891 and graduated from the University of Liege, Belgium, with degrees in mining, chemical, and electrical engineering. In World War I he served in the engineers corps of the Belgium Army, coming to the U. S. in 1926. He supervised the installation of processing equipment in zinc and lead properties in Oklahoma, Pennsylvania, West Virginia, and Colorado. He was a prominent mining engineer involved in research on the Mesabi iron range of Minnesota, where he began as a sales engineer for Reveleaire in 1929. His experience in European plants served him well here in his various positions.

Alexander N. Winchell (Legion of Honor Member 1901) died June 6, 1958, in New Haven, Conn. Professor Winchell was a prominent mineralogist and petrologist, acting as resident consultant at the Stamford laboratory of American Cyanamid Co. after his retirement. He held B.S. and M.S. degrees from the University of Minnesota and a doctorate from the University of Paris. After seven years' teaching at the Montana School of Mines, he joined the faculty of the University of Wisconsin in 1907, to remain until his retirement in 1944. He was also visiting professor at the University of Virginia and Columbia and was made Honorary Fellow in Geology at Yale after moving to Connecticut. In 1932 he was president of the Mineralogical Soc. of America, receiving its highest award, the Roebling Award, in 1955.

Necrology

Date Elected	Name	Date of Death
1924	Michael P. Cloonan	July 15, 1958
1954	George E. Harike	Nov. 28, 1956
1944	Clifford McIntosh	June 20, 1958
1913	E. M. Norris	May 7, 1958
1935	T. K. Price	May 13, 1958
1906	Joseph F. Thorn Legion of Honor	Oct. 25, 1957
1916	George G. Titzell, Jr.	May 27, 1958

Membership

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Society of Mining Engineers of AIME

Total AIME membership on July 31, 1958, was 30,380; in addition 3,111 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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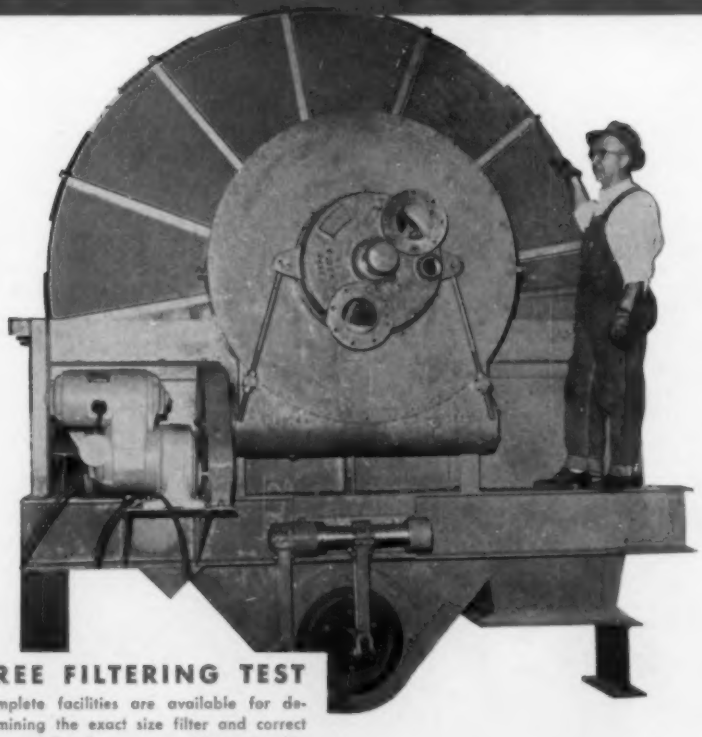

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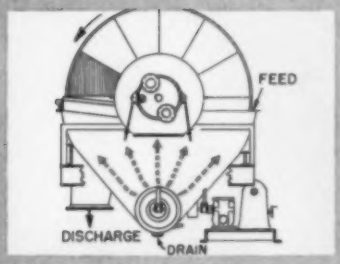

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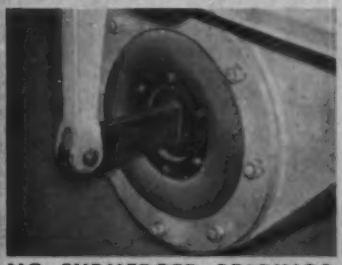

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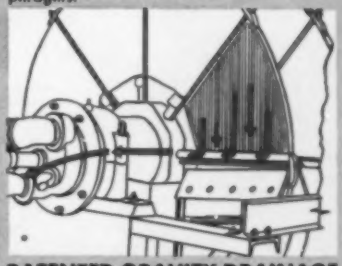

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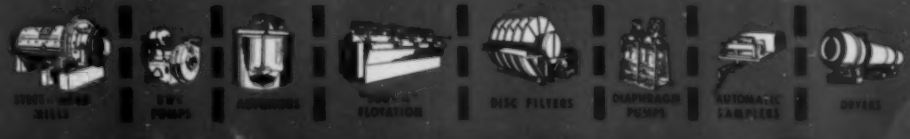

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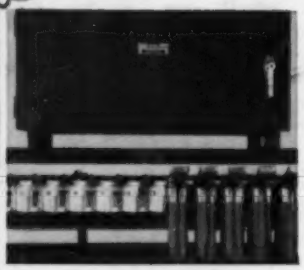

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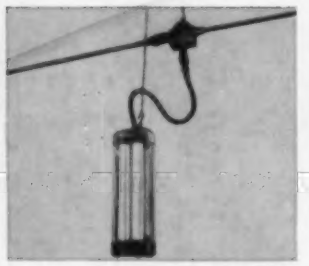

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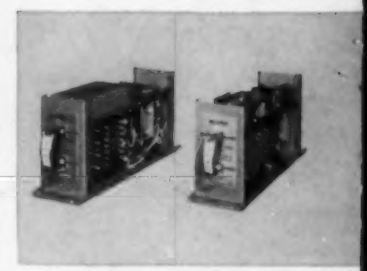

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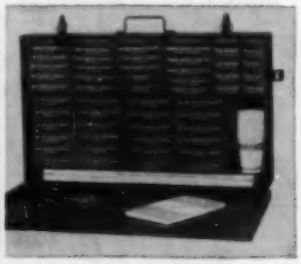

☐ **M-S-A MINER'S FIRST AID CABINET** provides medical dressings and equipment for mine hospital or dressing station. Each unit package individually wrapped in cellophane. When open, lid serves as a work shelf.

☐ **M-S-A ALL-SERVICE® MASK** with new Window-Cator canister, external check valve and M-S-A Cleartone Speaking Diaphragm gives dependable breathing protection against smoke, toxic gases and fumes.

☐ **M-S-A CHEMOX® BREATHING APPARATUS** completely safeguards breathing while travelling through any gaseous or oxygen deficient area. Generates its own oxygen supply from replaceable canister.

☐ **M-S-A SELF-RESCUER®** gives immediate breathing protection in emergencies caused by fire or explosion. Compact. Lightweight. Can be stored without deterioration. Available in storage cases or individual carrying cases.

☐ **M-S-A DUSTFOE RESPIRATOR** is light and compact for dependable protection against dusts, vapors, and mists. Allows maximum vision by the wearer. It's easy to clean. Design is modern and functional.

☐ **M-S-A CHEMKLOS** are made throughout of Dynel. These serviceable gray work clothes resist acids, caustics, mildew and moths. Styled for comfort and good looks. Available in coveralls, trousers and shirts.

☐ **M-S-A TYPE K SKULLGARD HAT WITH NEW FIXED CROWN SUSPENSION** is safest on the outside, safest on the inside. New suspension provides an extra margin of safety which is completely tamper-proof.

☑ CHECK ITEMS OF INTEREST

We will furnish further details

Check off the MSA products which you would like to know more about. Then tear out this ad, send it to MSA. We will send you the additional information requested.

Stop in and see us at the Mining Show in San Francisco: Booth 1500. We will be there with these products. An MSA representative will be pleased to relate the advantages of these items to your operation: in terms of full-shift protection, more tons per man.

MSA SAFETY EQUIPMENT HEADQUARTERS

MINE SAFETY APPLIANCES COMPANY
201 North Braddock Avenue, Pittsburgh 8, Pennsylvania

MINE SAFETY APPLIANCES CO. OF CANADA, LTD.
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